THE

ARCHITECTONICS

of

MODERN ARCHITECTURE

An Aid in the Solution of Architectural Problems

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With 895 Engravings on Wood

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PREFACE.

In the last of four works commenced at the same time and systematically completed, the Author presents to the Public a work, which is based on a thorough study of Mediaeval and Renaissance architecture, and is intended to elucidate the architecural problems of the present day in general and particular, in accordance with with the principles of Tectonics (Esthetics). It is in realtty a condensation of the intellectual work, that must be done in all architectural designing, so that if the conditions for a solution of the problem are given, one may easily and quickly find the corresponding form or motive.The form finally assumed by this motive depends on circumstances, and is the artistic work of the Architect. The book is at the same time a manual of architectural form and composition.

It is made possible for the architect to conncetedly review the more important ideas, to which his problem directly leads, so that nothing essential to the artistic treatment of his design may be omitted; he has only to decide what motive best corresponds to the problem, when merely the leading idea of i its form is given.

As in my Tectonics,I assign to construction the first place in the artistic treatment of Architectural and engineering structures. So far as the artistic form may be influenced by construction, I have sought to base it on constructive principles. One, who is guided by the principles of Tectonics, will correctly solve every problem. The result of this methodical procedure is a Renaissance style, modern in principle, more or less similar to the ancient styles and the Italian Renaissance, as well as to Mediaeval architecture. Here reason takes the place of any historical or traditional restraints; reflection decides what is right in any particular case; after reason attains its end, fancy enters on its right of endowing the motive already found with its proper form.

In many cases, I have restricted myself to the rules of the Dresden school, as being that in which Modern Renaissance architecture is most carefully treated, under the guidance of its excellent instructor, the late Professor Hermann Nicolai.

The fine-grained sandstone of Saxon Switzerland is employed for building in Dresden. Hence the dimensions are made as small as possible. Larger dimensions are common in other cities, xx

where harder stones are to be obtained. The usually massive dimensions of the Italian Renaissance are seldom found in our less brilliantly lighted North, which compels us to place the axes of the windows nearer each other. The Italians were compelled to soften the light to a certain degree, while we seek to concentrate it. The dimensions of Italian Renaissance buildings are therefore always either too massive or too weak,
buildings are therefore always either too massive or too weak,
if directly transferred to the North; too massive, because corresponding to a larger scale of the building; too weak, because intended for a stronger light. In many cases, it is best to be acquainted with a minimum rule, suited to our conditions.

The work will not be found exhaustive; many will miss what the consider to be of great importance, some will possess additional materials, while yet others may find certain portions treated too briefly or too fully. The Author will be contented, if the leading ideas are found usable, and are treated with sufficient fulness. Those persons, who have ever sought to consider abundant materials from a general point of view, will realize the difficulty of satisfying every reader and of writing a work, whose different portions shall be symmetrically d developed, neither too broadly nor too concisely.

The great number of woodcuts required for the work, necessitated the simplest mode of treatment. As the book is intended for the use of architects, who have passed through their period of study, it is proper that the sketches should only be sufficient to be clearly understood, just such as are drawn by the instructor on the blackboard with crayon.

For the benefit of those desiring to use the work, who neither possess nor are acquainted with my Tectonics, the most important conclusions of that work are briefly collected; they are leading ideas of decided importance.

Berlin. Jan. 1883. The Author.

Recapitulation of the more important laws of general Tectonics.

Section 1. Esthetic Principles.

1. The esthetically agreeable is only unity in itself, or a unity composed of many.

2. The mode of connection of the many must either be evident of be easily divined.

3. A deviation from unity is disturbing, if without sufficient reason.

4. With a sufficient reason, this deviation produces a greater pleasure than unity, since it is the beginning of variety.

5. The simplest form of variety in unity, for all visible things, is Symmetry.

6. From a higher point of view, equilibrium surpasses symmetry in agreeableness.

7. The unifying connection of the many excludes everything incommensurable or incomparable, as a disturbing element.

8. From a higher stand-point, the unifying connection of the many must accord with an idea,suggested by the whole, we term this requirement, which must be satisfied, that of internal truth.

9. Further, the whole must harmonize with the subject, which it represents, or with the purpose it subserves, and with the means of its realization. This is the requirement of external truth.

10. The agreeableness changes with the component factors, connected with the appearance of unity or variety. The whole must be in harmony with these associative factors.

11. Variety demands contrasts of complementary peculiarities. Contrasts may only occur between comparable things. Contrasts require preparation, adjustment or solution. Groups of contrasting effects may be combined together, thus enhancing the effect of variety and unifying connection. The results of contrasting effects consist in converging or diverging, gradual or rapid, increase or diminution of pleasure or disgust.

12. As in nature, so in art and tectonics, the end must be attained in the simplest way. The complete harmony of form and purpose is the indispensable requirement of all beauty in tectonics, and demands the absolute purity of the external appear-

appearance of the object, as the lowest step of the beautiful, on the one hand, on the other being the agreement of the quality of the form with the purcose.

13. The principle of internal and external truth implicitly comprises the requirement of the characteristic, i.e., of the prominence of the distinctive characteristics of different things; idead aims require the placing of those things of secondary importance in the background, on reasons of essential propriety or conventionalization, that modification of form, required by the purpose.

14. Symbolization, or the representation of what cannot be directly represented by means of external signs, comprises the personification of general conceptions, of religious ideas, whose reality is only perceptible to the mind, or which are invisible or too great to be seen as a whole, of complex things by a simple token. Symbolical acts, ceremonies and objects, and monuments, are means of expression for the personification of Art.

Section II. The geometrical Element in Tectonics.

1. The point is the symbol of unity because it is the simplest geometrical construction.

2. With a pair of points is connected the idea of symmetry and equilibrium, according to their relation to a horizontal plane, Whether right and left, above and below, before and behind it, and whether the line joining them is divided into equal or unequal parts.

3. The point as beginning, middle or end point, focus or centre of gravity, requires special prominence as a unity, in tectonics, where it is the special in the general, and is characteristic. An intermediate point only needs to be accented.

4. The division of a linear magnitude into two or three equal parts is pleasing from its symmetry, or as a group, if the middle part be prominent; if the middle part be less or greater than the side parts, the second group is more pleasing than the first, on account of the accent placed on it.

5. Divistions into three, four or five parts, are pleasing if the middle or end parts are accented.

6. With a division into more than three, four or five parts, the whole loses its distinctness, and its agreeableness diminishes.

7. By division into a great number of parts, the series represents a conformity to law, whose agreeableness increases, if it be composed of periodically recurring divisions and groups, enhanced by interruptions.

8. The grouping of individual points around another may follow a centric or excentric arrangement.

9. The division of a surface may be:- a, linera; b, according to two rectangular axes, o to three axes making angles of 60° with each other; c, according to axes independent of the forms of the elements of the surface; d, centric or excentric.

Linear division of surfaces may occur, which consists of really harmonizing elements, in which both directions are equally accented, right and left of the longitudinal axis, and therefore equilibrate each other, or in which these differ from each other.

10. Division of surfaces according to two or three axes, we term web systems; that according to axes independent of the form elements, we call embroidery, mosaic, braid, lattice, knit, chain, net or cell systems, according to the mode of construction employed.

11. The centric and excentric division of surfaces produce radial and spiral arrangements.

12. A great many regular mathematical curves, never employed in Art, possess a decided esthetic importance as forms of motion.

13. The distribution of points in space may be placed under one of the systems of crystallography, regular, quadratic, rhombic, hexagonal, as well as under the three clinical systems with inclined axes.

14. Spaces may be divided by planes into cubic, parallelopipedic, rhombohedric and tetratedric elements, and by combining these forms, it may be entirely occupied by rhombic dodecahedric elements.

15. With the ideas of above, below, right, left, before, behind, within and without, are associated the ideas of values, and with these are joined those of coordination, subordination and independence.

Section III. Form.

I. The Form itself.

1. Nothing belongs to pure perception, that lies within or

without the form.

2. The more completely the peculiarities of the ground forms are presented to the actual perception, the more favorably they appear to the esthetic sense.

3. The more the characteristic relations of pure perception are changed to actual perception, the more useful will these be in esthetic respects.

4. Crystalline forms are actually perceived by means of the prominence of their angles, edges and surfaces, and this is made possible by the optical peculiarities of the material. To make the axes visible, mark the angles, central points of edges and surfaces, and planes of cleavage, which assists the actual perception.

5. Round bodies only appear in relief through optical peculiarities, and this appearance is heightened by meridians, by drawing generatrices, and by the actual prominence of axes, centres,and foci, as well as of tangential surfaces.

B. Relations of purpose and form.

6. Every form that hinders the attainment of an end is to be avoided in Tectonics; every other one is to be sought, which may further the satisfaction of a purpose.

7. One important condition of the form treatment lies in the capability of combination of the elements of a structure.

8. The capability for separation of a construction may determine its form treatment.

9. The form may be determined by the purpose, in that in general it cannot be found, unless the latter is given.

10. The form may be entirely independent of the purpose.

11. The selection of a form may thus far be determined by the purpose, that by its means the end may best be attained.

12. The form,theoretically most tasteful may be less adapted to fulfil a certain purpose than another, owing to accidental circumstances.

13. A modification of form is permissible, through the possibility of the misuse of the peculiarities of an object for another purpose.

14. Modification of forms may be required by the number of modes of application.

15. The forms may remain constant, even if the purpose be lost.

16. The modification of forms depends on the number and succession of the purposes for which, and according to which, the article may be employed.

17. The capacity for use lessens with use.

18. The construction may be destroyed by a single use.

19. Form may be defendent on an entire series of purposes.

20. If several peculiarities of an object be simultaneously applied to several purposes, its form treatment is a function of its peculiarities and its purpose.

21. If these peculiarities be employed for different purposesat considerable intervals of time, the form may change in accordance with the purpose and peculiarities.

22. If a series of purposes are subordinated to each other, their succession determines the form treatment.

23. Coordinate purposes require a form treatment which takes both into account.

C. Relation of Material and Form.

a. Relation of coherence.

24. Forms of uniform resistance are employed for economy of weight, material and work, or of cost; the difficulty of constructing these causes the preference of approximate forms to those theoretically correct. Forms of absolute resistance are not only preferable for all structures subject to intense forces, but are most pleasing, since their capacity for resisting strain is apparent.

25. The use of approximate instead of exact forms of uniform resistance is an expedient for varying and animating the outline, while retaining the same enveloping form.

26. In case of bodies subject to but small external forces, forms of uniform resistance are to be avoided, and more decided changes of cross section are required.

b, c. The Material, its preparation and combination.

I. Building Construction.

A. Building Materials.

27. General laws for the form treatment of building materials cannot be established; they change with the quality of the material and the purpose to which it is applied. But the following are valid in special cases.

Hard stones, wrought with difficulty, should be dressed as

little as possible and be simply treated;if polished,slight c curvatures are preferable for small forgs, strong curvatures for large ones. Softer stones, like serpentine and marble, may be turned.

28. Hard stones wrought with difficulty, as well as coarse grained stones and portous stones, are generally suitable for those structural uses in architecture and engineering, which are subject to severe external forces.

29. Uncoursed stones correspond to Cyclopean masonry, coursed stones to squared stonework.

30. To save work and obtain a stronger bond, the stones should be as large as possible.

31. Parallelopipedic blocks of stone composing the parts of a structure require a suitable mode of jointing to save material and work; the joints should never be employed as a purely decorative expedient where no joints are required by the construction. Parts of the building may be divided by joints, but the height of its members should never exceed the maximum height possible of quarry bed.

32. The fineness of the grain and the magnitude of the forms employed, as well as the distance from the eyes of the observer, determines the mode of cutting employed for the external surface of the stone, and the direction of the strokes must be suited to the downward flow of the water.

33. The beauty of dark stones is much enhanced by polishing, that of light stones but slightly.

34. The forms of bricks may be similar to those of soft stones, if unburnt; like those of hard stones, if burned.

35. The forms of pressed bricks should be bounded by plane or cylindrical surfaces, or be impressed by a mould.

36. The forms of modeled and burned clay are limited in dimensions, relief and projection, by the shrinkage and cracking of the clay, as well as by the difficulty of an uniform burning, and by the flexibility of the material.

37. The dimensions of a brick determine the dimensions of all ornamental terra cotta blocks, and of blocks of cut stone used in the same construction, and limit the size and choice of forms of section, but admit of a peculiar decorative and constructive treatment, which gives a peculiar character to brick masonry.

38. Cement concrete used as a building material is subject to the same laws as other cast materials, or if wrought after hardening, is to be treated in the same way as cut stone.

39. The working of wood produces parallelopipedic and cylindric forms, turned forms, and reliefs in endless variety, obtained by carving. Many forms can be produced by bending and by pressing the material.

40. The slight strength of wood perpendicular to the fibres requires that the figres be cut as little as possible, and the form treatment is limited in respect to this point; but in hard and dense woods, this may be neglected, deep incisions and fre-interruptions of the fibres may occur, and an animated alternation of slight and strong curvatures is required.

41. The forms of cast iron are entirely dependent on the mould, pattern, the process of casting and the withdrawal from the mould. It may be said in general, that cast iron is preferable for thin objects, plates or thin-walled articles, that t the difficulty of working its external surface requires the casting to be as smooth as possible, that its great strength makes it peculiarly adapted for strongly loaded parts of a structure, for which forms of uniform strength are to be recommended on account of economy of material, as well as strengthening ribs, perforations, and thickened surfaces, in proper places.

42. Wrought iron requires simple and slender forms in construction of as large dimensions as possible, the rounding-off of projecting angles, gradual transitions and diminutions, and in engineering structures a restriction to the use of bars of the usual trade sections and forms.

43. Forged work demands gentle curvatures and smooth transitions, flatness in thick plates, variety in thin ones.

44. Supplementary work on the external surface of wrought iron is to be avoided, unless absolutely necessary.

45. If wrought iron be employed for articles whose strength far exceeds the strains to which they may be exposed, the greatest varietw of forms is admissible.

46. Steel combines the good qualities of cast and of wrought iron in the highest degree, and therefore it allows a wider range of form, as well as the use of very thin or very massive

parts, and is especially remarkable for its tempering colors, and a capacity for receiving polish.

47. The excellence of copper consists in its adaptation to all hammered work, with its fine polish and beautiful color, and also the fine color and durability of its oxidations.

48. Brass and red brass unite a special suitability for castings with most of the peculiarities of copper.

49. Lead and zinc may be employed for cast and wrought work, as well as for perforated work in plates.

50. Tin with its silvery white color, bright lustre and resistance to oxidation, is suitable for fine castings as well as for tinning.

B. Building Constructions.

51. Stone constructions are jointed structures, forming walls, supports, ceilings and pavements.

52. Wooden constructions comprise the lengthening, deepening, widening and jointing together of timbers,to form walls, supports, ceilings, floors, panelings of all kinds, frameworks and other structures.

53. Metal constructions are connected by means of rivets, b bolts and keys, employed in engineering for form and structure similar to those of wood, and especially in mechanical engineering for moving machines, subject to both force and vibration.

II. Joinery; Locksmith's work. (Metal work).

54. Joinery usually employs boards and scantlings of small dimensions for thin partitions, light ceilings, floors, stairs, doors and windows, railings and lattices, and lastly for furniture.Works in joinery are light structures, whose forms depend rather on economy of material used than on their purposes, and they are connected by panelings, mosaic joints, framings and latticings of all kinds.

55. The works of the locksmith, like those of the joiner, d differ from those of the principal portions of a structure in that the element of weight is less prominent than that of strength; like joinery they are composed of bars and plates, of overlays and trimmings, and they likewise possess a wide range of forms. Wrought, bent and stamped, with iron parts turned about a longitudinal axis, bars and plates rolled into volutes and springs, perforated plates, etc., these are the elementary

forms peculiar to locksmith's work.

III. Textile Art.

56. From flexible, tough and fibrous materials, textile art produces wickerwork, woven fabrics, embroideries, knitted and netted networks, chain works, felts, on the basis of the division of surfaces given under II, 9 and 10.

IV. Mosaics.

57. Joinings whose strength depends on a cementing material and whose forms are based on the mosaic system.

V. Metallotechnics.

58. This especially comprises small art works, employing the nobler metals and the finer alloys of copper, in addition to the metals classed as building materials. The processes are t the etching of alloys, polishing, chasing, damascening, engsaving, etching, gilding and silvering, plating, stamping, incrustation, niello work, filigree work, and the setting of precious stones.

VI. Tectonics.

59. Tectonics in a limited sense produces in a hard material turned and inlaid works.

VII. Enameling.

60. Enameler's work is principally glass making and comprises the treatment of cast and pressed materials, as well as glass blowing, flashed anf filigree work, and the art of enameling.

VIII. Ceramics.

61Ceramics is chiefly the fashioning of pottery, and like all other technical industries employing clay, it is subject to t the control by its peculiaritieson the one hand, by its remarkable plasticity and adhesiveness and its burning to a porous, fritty or glassy mass, on the other by its injurious peculiarities of shrinkage, of being easily broken or bent out of shape, and of being uniformly burned with difficulty.

IX. The Art of Form.

62. The art of form in pure relief is entirely free in the choice of form, only being restricted within certain limits by the material employed.

d. Relations of light and shade.

63. The strength of relief in the form must harmonize with the average intensity of sunlight in the place considered,

and with the degree of brightness of the colored materials, and must also increase or diminish inversely as these conditions.

64. Nearer objects appear brighter than those more distant, and conversely, brighter objects appear nearer than darker ones.

65. As the object is removed from the eyes of the observer, the fine gradations of light and shade are lost, the object appears indistinct and as if vanishing; conversely, indistinct objects appear more distant than if distinct, and the form must be sketch like, to obtain greater distinctness, if it be distant from the observer.

66. Irradiation may cause an exaggeration of form, according to the location of the object, with reference to other bright or dark objects.

67. The optical deceptions of the relations of the dimensions and their direction require consideration.

68. The greater the number of other articles between the observer and the object, the more distant will it appear, the fewer, the nearer will it seem.

69. Transparency of the material lessens the depth of shadows and the releef effect, which diminishes as the transparency becomes more perfect. Transparency represents the light, weak and fragile, therefore transparent materials are not employed for structural parts, but only for decorative purposes.

70. Reflecting surfaces emit widely distributed light rays if plane or slightly curved, or sharp and concentrated rays if strongly curved. Materials having polished and mirror-like surfaces generally exhibit sharply distinguished masses of light and shade, and reflections, while materials of weak reflective powers show soft transitions and reflections, hence the propriety of sharper and gentler curvatures in the form of weak reflecting powers; we permit sometimes one and sometimes the other to predominate.

D. Symbolical Forms.

a. Relative Forms.

I. Limiting Forms.

71. Limiting forms indicate the beginning or termination, or have the relation of nucleus and enclosure. Beginning and terminal forms are:- a, disconnected at top or on both sides; b,

disconnected at bottom; c, connected ends of horizontal struts; d, connected ends of horizontal ties; e, connected ends of supports; f, connected ends of tierods. Disconnected and connected terminations must always express that by their own strength, they have formed themselves so to terminate, or as if their forms rose spontaneously against the resistance. A spiral form of decoration is appropriate for ties and tierods, and longitudinal stripes for supports and struts, and connected terminations have functions similar to those of the human head, foot and hand, since these are opposing and fixing members.

72. Limits of surfaces are to be so formed, that the material may appear self-limited on its edges, or shade off freely towards the centers of openings, or be enclosed by bounding forms of all kinds. Divisions of surfaces require different forms of borders and of adjacent parts, expressing the alternation of the two portions.

2. Transitional Forms.

73. Intermediate forms transform one cross section or direction into another.

74. Arrangements of forms indicate separated yet re-connected parts, and may personify the strength of the connection, the new relations of both parts to each other, of one part to the other, or of neither part to the other; they can indicate preliminary or terminal, completing or free terminal forms, or direction in general.

75. With convexity and concavity are associated the representation of repulsion, aversion and exclusion, on the one hand, on the other, those of admission and reception; the first serve well as bearing, the latter for changing and terminal forms.

76. The divisions will be conceived to be necking and footing, as well as connecting members, in the sense of the decoration of the human body.

77. Separate divisions of groups of members are separated by fillets, coves, rounds and small mouldings.

b. Decorative Forms.

78. The highest application of ornamental forms is, like that of relative forms, to represent the material as if animated, i.e., when the external form corresponds to the purpose subserved. The simplest application is to render a unity or a single

point more prominent. A second application is the characterization of symmetrically arranged points, which are subordinate to a single point.

79. Ornamental forms corresponding to a centric arrangement take the form of wreaths, necklaces, rings, girdles and bracelets; to the excentric arrangement correspond the palm ornament, branches of flowers and masses symmetrically arranged about a focus, certain directions being accented.

80. A third group or ornamental forms are continuous motives for characterizing a certain direction, whereby other directions are made prominent.

Section IV. Proportions.

1. The unit of scale of all human works and structures in Tectonics is man himself, but the mass depends on the weight of the material, increasing as the cube if the dimensions increase in three directions.

2. The permissible limits of dimensions in Tectonics depend on the distance of the object from the observer.

Section V. Coloration.

1. The simple colors are red, yellow, blue; the mixed colors are green, orange, violet; red,yellow and orange are active, green, blue and violet are passive colors. Complementary colors produce the most marked contrasts. Color arrangements have different esthetic values according to the predominance of active or passive colors, to the representations with which they are associated and the brightness, intensity and specific importance. Representations in Tectonics may strongly influence coloration, compelling us to a more restricted choice of pigmentsthen striving to attain harmony, preferably by shading off these colors.

2. Black and white, silver and gold, strongly contrast with colors; black and white modify the degree of brightness of colors by irradiation; metal placed between colors intensifies these contrasts, and if sprinkled over the surface lends a festive character to the coloration, but suppresses the color effect by its preponderance, yet this can only be excelled by the gleam and play of the precious stones.

INTRODUCTION.

By Architectonics is meant the science of the treatment of architectural forms in accordance with the principles of Tectonics (Applied Esthetics).

The building is the problem in architecture, and it serves the most diverse purposes of a habitation, for public life and assemblies, as well as for religious worship.

Since we pass from the special to the general in order to obtain an understanding of the subject, we shall first discuss the parts of the building, next the building itself,and lastly the grouping of buildings and the planning of cities.

Our design in the following pages is always to trace out the motive in a special problem, which offers itself for artistic treatment.

If with Semper, we were willing to recognize the problem of Tectonics in the external covering, we might envelop an object in any decorative covering whatever, which seemed suitable for the puspose on external grounds, but having no real connection with the internal nature of the object. A wall would then be merely the enclosure of a portion of space, like a suspended curtain or mat, and in accordance with the external covering system, the wall might be constructed in any manner whatever, only requiring merely to be covered by any kind of protective coating, on which might be painted, carved or stamped any desired tapestry patterns.

Granting that the covering principle predominates in the earlier architectural styles of the past, as Semper tried to prove, this furnishes no evidence that it would be an inartistic thought to take the construction as the starting point for the structural form. Architecture commences with the construction and stops when nothing remains to build. Hence, we shall pursue the other course and attempt to derive the architectural motive from the construction. If our results sometimes conflict with those of the other theory, we can content ourselves with this, that the adherent to the form theory may also find something of acknowledged value in our discussions; and if Semper not infrequently assumed the principle of construction as a starting point, we shall so far accord with him.

We shall always regard our subject from the technical, hist-

historical and esthetic point of view.

The special topics to be treated are first, the essential p parts of a building, space-enclosing and bearing walls, ceilings and their detached supports, floors, openings, connection of stories, and roofs.

Architectural structures are executed in stone, bricks, wood, metal, and their combinations.

Buildings for various purposes, Grouping of buildings in bl blocks or quarters of a city, Plans for business buildings and accessories, ending with Decorations for festivals.

Our programme is as follows.

A. Space-enclosing walls.
   1. Stone masonry.
   2. Brick masonry.
   3. External cement plastering.
   4. Wooden walls.
   5. Half-timbered walls.

B. Ceilings.
   1. Of stone beams.
   2. Of wooden beams.
   3. Horizontal iron ceilings.
   4. Visible trusses of wood or iron.
   5. Vaults.

C. Supports.
   1. Columns.
   2. Piers or pillars.
   3. Entablatures of stone, wood or iron.
   4. Arcades; stone bridges.
   5. Buttresses and flying buttresses.

D. Openings in walls.
   1. Windows.
   2. Wheel windows.
   3. Doors.
   4. Gates.
   5. Portals of tunnels.

E. Floors.
   1. Pawements of stone or wood.
   2. Floors of stone slabs.
   3. Floors of bricks or tiles.

4. Mosaic floors.
5. Floors of cement.

F. Buildings in several stories.
1. Height and character of stories.
2. Bases, string courses and cornices.
3. Stories not separated by horizontal divisions.
4. Galleries, balconies, bay windows, pedestal courses, corbelled constructions, spandrels, balustrades.
5. Stairs.
6. Towers. (Also bridge towers).

G. Roofs.
1. Batter of walls.
2. Forms of roofs.
3. covering of roofs.
4. Dormers.
5. Ridge turrets.
6. Chimneys.
7. Decorations.

H. Stone construction.
I. Brick construction.
K. Mixed stone and brick construction.
L. Wood construction.
M. Mixed stone, brick and wooden construction.
N. Metal construction. Iron vaults.
O. Mixed stone, wood and iron construction.
P. Arrangement of plan.
Q. Cross section of buildings.
R. Facades. Facades on courts.
S. Kinds of buildings.
T. Plans of cities. Public squares, streets, gardens.
U. Wells and fountains.
V. Memorials. Seats.
W. City gates. Triumphal arches.
X. Bridges, ramps, canals, Basins for water.
Y. Lighting, lamp posts.
Z. Decorations for festivals.

A. Space-enclosing walls.

1. Stone masonry.

All masonry is formed by the superposition of uncut , partly

or entirely dressed, natural or artificial stones, with coursed or uncoursed joints, with the addition of mortar or cement, d dowels or cramps set in lead, sulphur or cement, or the stones may be joggled or dovetailed together. In masonry, the first point to be consedered is the bond of the stones, i.e., the laying of one stone on another in suca a way that the stability of the wall without mortar shall be as great as possible.

The requirements of a good bond are that the upper stones shall always cover the joints of those next beneath; further that the external surface of the masonry, which is to be regarded as a covering for the protection of the interior, is firmly connected to that inteeior of the wall by long headers or bond stones, while the other stones or stretchers do not extend deeply into the wall, only serving to fill the interspaces.

a. Rubble masonry of boulders.

Simplest and cheapest, though least durable kind of masonry. Rubble masonry of boulders is very common in countries where stone is quarried with great difficulty; it is composed of boulders found in the beds of rivers or scattered in the fields, or are the widely dispersed erratic blocks, as in north Germany; considerable quantities of Swedish and Norwegian granite are faund there, sometimes of large size, as well as great heaps of boulders, probably transported across the North sea from northern countries by ice floes far into the northern plain and deposited there. Such erratic boulders were even carried into Holland from northern Scandinavia by masses of ice, and the entire North sea is paved with them.

Still, though masonry of tolerably round split boulders was much used in the low northeast plain of Germany for mediaeval and later buildings, the broken surfaces being set visible, this imperfect masonry of small stability is entirely lacking in Holland. This rough rubble requires the walls to be of great thickness, and the interspaces are partly filled by spalls, b but demand a large quantity of mortar. In the Mark of Brandenburk and adjacent parts are found several old churches, entirely built of this masonry, , as well as the lower portions of towers and churches, with the upper parts of bricks. This masonry can be somewhat strengthened and decorated by occasional

courses of bricks. (Fig. 1). But in general it is imperfect and is only to be regarded as permissible in exceptional circumstances, or as possessing some value for subordinate purposes, on account of its primitive appearance. As a covering for railway embankments, it becomes a kind of paving.

b. Cyclopean masonry.

A higher development of masonry consists of irregular stones, mostly uncut though carefully selected and roughly prepared, is found in the polygonal masonry known as Cyclopean since Pausanias, producing firm construction by means of the closely fitting polygonal blocks. Its nature and existence depend on the fact that it is only suited for uncoursed stones quarried in irregular masses. It was frequently used in ancient times in Greece, Asia Minor and Italy for city walls, fortifications, and royal fortresses, possibly because the removal of one or more stones would not cause the fall of the masonry. Semper rightly called attention to the existence in it of arched construction in a latent form. The walls sometimes have a thickness of 26 feet, the largest blocks measuring over 9.75 ft.

That Cyclopean masonry was even employed in the temples of the Greeks is proved by an example taken from the temple of Themis at Rhamnus, a portion of the walls being shown in Fig. 2, with in Figs. 3 and 4 two other specimens of the walls filling the spaces between the side walls of the vestibule; it is evident that the stones are fitted together with the greatest care, so as to obtain unity of effect joined with great variety, this having been erected at the time of the complete development of Doric architecture. In very recent times this polygonal masonry is executed in granite, porphyry or volcanic stones and limestone breaking irregularly, and is employed for walls where an appearance of unusual stability and primitiveness is desired, for example for retaining walls of terraces and slopes, as in the substructure of the Walhalla near Regensburg, the retaining walls of the Black Forest railway, and in the fortifications of Verona, of which a specimen is given in Fig. 5. The quay walls and fortifications of Cologne and other places are built of basalt and trachyte prisms from Siebengebirge and are somewhat similar, being composed of long prismatic blocks of polgonal section.

Similar polygonal masonry of basalt from Vogelsgebirge is to be found in the castle of Mönzenburg in Wetterau province.

Polygonal masonry of small blocks with dimensions not exceeding 2 ft. are uncut and chenked with spalls, and are found in the road buildings of Saxony using the diorite from near Plau.

All these kinds of polygonal masonry are in form based on t the mosaic system composed of irregular elements, and they produce a very pleasing effect if properly executed, by their unity of idea with great variety.

The Romans always employed masonry composed of wholly irregular small stones bedded in excellent mortar, from which resulted the extraordinary strength of this kind of masonry, the "opus incertum." The angles and edges of the masonry were usually strengthened by brickwork or by blocks of cut stone.

A very perfect polygonal masonry might be composed of right rhombodecahedrons. (Baumeister. Architectural forms for Engineering). These might be of different sizes and also distorted, if so arranged to fit closely,with no interspaces left between them. But the ideal type of polygonal masonry would be the one already considered in Tectonics in the Chapter on the division of space, and composed of similar elements with an absolutely rigid bond. If we examine the two specimens of walls from the temple of Themis at Rhamnus, it is evident that this polygonal masonry fails in two important particulars, which make it inapplicable to detached pillars, and therefore requires the angles of the walls to be strengthened by another kind of masonry. The lack of horizontal courses would cause pillars of polygonal masonry to separate by sliding, and as the masonry tends to yield, a horizontal thrust acts on the inclined beds and must be resisted by firm abutments. A pleasing specimen of polygonal masonry must show as great variety as possible, still retaining a decided union of the elements; this is adapted to the richest possible diversity of form of the elements, not too diverse, with the limitation of their dimensions within two limits, the greater being fixed by the nature of the material, and the lesser by the condition that the polygonal masonry shall not seem to be composed of large blocks with intervals filled by small ones. Since the separate blocks are not only subject to transverse strain as well as to compression, their widths should not

differ too much from their heights. If it is generally correct not to form reentrant angles on long stones, and to use right or acute angles but seldom, to also avoid the meeting of less or more than three joints at a common point; to make but moderate use of triangular or trapezoidal blocks, excluding all horizontal and vertical joints, these forms and arrangements should not be neglected, in order to enhance the variety in its effect.

It appears to us superfluous to require that polygonal masonry should only be employed in walls having some batter, so that one may not fear that a single stone might fall out of the surface of the wall, since polygonal masonry is scarcely used without the use of cement or mortar.

To cut the face of polygonal masonry is an extravagance, a draft may be cut around the margin of each face with the width of an ordinary chisel, but it is tasteless to dress the entire surface otherwise than in the most superficial manner. The entire labor should be devoted to a careful selection of the stones and to fitting them accurately together. If the polygonal bond is exceptionally employed with finely wrought architectural details and surfaces of polished stone, as in the temple of Themis at Rhamnus, this might be due to traditional or symbolical reasons. Polished surfaces of Cyclopean masonry are opposed to the character of massive strength and primitiveness. Other considerations are applicable to the pavements of streets like the modern streets of Florence and the ancient streets of Rome, than to Cyclopean masonry, since these pavements are not structures, but are simple mosaics.

In Grecian architecture a kind of masonry was employed intermediate between Cyclopean and rubble masonry, since the joints are partly polygonal and partly horizontal. In Fig. 6 we give an example from Mantinea and two others after Viollet-le-Duc, which are very interesting, though seldom imitated at this time. Many kinds of stone break with approximately rectangular reentran angles as in Fig. 7; others have parallel beds and oblique ends as in Fig. 8; it was proper to use these natural beds and end joints for obtaining a varied effect in the appearance without too much preparation. Engineering construction is accustomed to work on a large scale and must take

economy into account, may perhaps make use of such bonds with advantage.

c. Rubble masonry of quarried stones.

While the kind of rubble masonry just described was composed of stones of wholly irregular form, quarried rubble masonry is built of stones with beds and laid in courses just as they come from the quarry, or after very rude preparation. The stability of masonry of irregular stones depends on the careful filling of all interstices with stone spalls and good mortar; of polygonal masonry on the exact fitting together of many blocks; that of quarried rubble masonry is dependent on the regularity of bond, the horizontal position of beds, the breaking of vertical joints, and the use of long headers. This kind of masonry is appropriate for stratified sandstone and limestone, for slaty sedimentary and volcanic rocks. No acute angles or edges or oblique joints are found in it; the joints must therefore be properly filled with mortar and the wall be covered by it, if a smootn and uniform surface be desired; the angles and edges must be strengthened with brickwork or ashlar masonry, as in Fig. 9, if they are to appear sharp and distinct and to be strongly coherent.

As in polygonaland also in coursed masonry, the separate stones are only subject to crushing, though this is absolutely t true only of entirely homogeneous masonry with all beds horizontal. To prevent the fracture of a stone, its length should not exceed 3 to 5 times its height.

The Romans, and after them the mediaeval builders, were fond of using the herringbone bond or opus spicatum for the external surfaces of walls,built of ordinary coursed masonry. This (Fig. 10) is composed of stones partly from river beds, partly of q quarried stones or bricks, and it was employed from the late Roman period until in the 14 th century.

We will examine the different kinds of herringbone masonry of brickwork. Since the stability of the bond is not great, horizontal courses of bricks are placed at regular heights. The example in Fig. 11 is found in the facing of the walls of Ravenna erected by Theodoric of Verona in the 6 th century A.D.; the masonry is built of stones taken from the bed of the river Adige, mixed with courses of bricks. During the med-

mediaeval period this bond was common in the castles of the knights, and it is occasionally found in churches; we have an example in the castle of Hohenrathia in Graubunten (Fig. 12), in which only quarried stone is used.

Other examples are found from the 10 th to the 12 th centuries in the walls of the city of Fulda built in 1166, in Regensburg and Würzburg as well as in other cities, none of which are later than the 12 th century. This herringbone bond was long employed in brick construction as in the mediaeval opus spicatum. Fig. 13 is from S. Ambrose at Milan and Fig. 14 is from Verona, fragments of cylindrical tiles being used in the latter.

The angles in this form of masonry always required to be strengthened by ashlars or brick quoins, with horizontal beds. It produces rather the impression of great stability against sliding than that of great strength.

By the use of quarried stones with parallel beds, some kinds of bonds are possible in addition to those ordinarily employed, and which were used during the middle ages and may still be recommended as being a simple means of increasing the variety in appearance of the masonry; we refer to quarried rubble masonry with courses of different heights, like the tufa masonry of t those portions of the church of S. Gereon at Cologne erected during the 11 th century, as well as in the substructure of the castle of Meissen begun in 1478. (Figs. 15, 16). All these kinds of masonry are suited to local conditions, to the materials obtainable, and to the purposes to which they were applied.

A mode of treating quarried rubble masonry employed in the Roman period, and imitated in the early middle ages, deserves mention here; it consists of the use of stones with irregular beds and without true end joints like tufaceous limestone;Very thick joints were filled with mortar so as to make the masonry even and smooth, regular end joints being later incised in the soft mortar (Fig. 17). This kind of masonry is found until the 12 th century in the walls of churches, fortresses and the walls of fortifications, and it is still used in the vicinity of Evreux, where only volcanic rocks are commonly employed.

If the quarried rubble masonry of the middle ages was strengthened by ashlars at its angles in both plastered and unplast-

unplasterad walls, it was usual to have no vertical end joints between these blocks and the wall, but irregular ones. (Fig. 18). This gives a picturesque character to the masonry, which is sought in all economically constructed buildings as the only means of obtaining a simple and Tectonic treatment. The Renaissance first abandoned this method and constructed masonry of a very regular series' of ashlar blocks. All kinds of irregular masonry, comprising Cyclopean and those kinds forming the transition to ashlar masonry, bear the character of unpretentiousness, necessity and economy; the Roman and Renaissance builders applied to them as well as to roughly wrought ashlars the terms "rustic", boorish or rural, as a distinction from t the regular and smotthly dressed masonry of the more prominent buildings of cities. However inappropriate may be these terms, they are not easily replaced by better ones. To soften the effect of this unassuming but picturesque masonry by representing the joints, either making them as thin as possible or by giving the mortar the color of the stone, is the error of a narrow-minded pedant, never adopted in any good architectural style. The irregularities of the masonry require a good bed of mortar, and this bed must be visible as evidence of the durability of the masonry. To subordinate the joints is to dispense with the only means of securing a certain variety in appearance without too great cost. Unity must be sought, not in uniformity of appearance, but in the principle controling variety, and which must appear unless the work is to seem insipid, without character and weak, qualities unfortunately too commonly preferred by the modern architect and engineer to the picturesque, natural and strong.

d. Ashlar masonry of small stones.

A mode of construction common in all Roman provinces is die work, a kind of incrustation on walls, composed of small pyramidal stones 3 to 4 or rarely 6 to 7 inches square set with b broken joints in a very thick coat of mortar (Fig. 19).

This die work is interrupted at antervals by courses of bricks deeply bonded in the wall. This masonry is especially common in Gallo-Roman buildings, but it long survived the fall of the Roman empire in central France; the only known examples of it in Germany are the Clara tower at Cologne and the imperial

palace at Treves.

The Roman network or opus reticulatum is allied to this die work and is composed of pyramidal blocks of tufa, 3.5 to 5 ins. square (Fig. 20), a specimen of which from Pompeii is given in Fig. 21. The network and the die workare specially ornamental bonds for facing concrete masonry. They are seldom used in recent times excepting for paving streets.

A kind of masonry composed of small and regular, but rudely cut oblong stones with thick joints, was in general use by the Romans in France and Germany; this so-called paving masonry was also much used in mediaeval structures and is still preferred in countries furnishing easily wrought materials, like the Brohlthal tufa and the variegated sandstone of the middle and upper Rhine provinces.

e. Ashlar masonry composed of large stones.

Ashlar masonry proper will next be mentioned, and it requires to be considered in three ways; mode of preparation of the stones, the bond, and the means of fixind and clamping the ashlars together.

a. Mode of dressing.

If the blocks of stone are quarried with powder, fire, or a row of wedges, they are wrought to form dimension stones, i.e., blocks of prescribed dimensions with approximately rectangular surfaces, still rough and uneven, leaving about an inch to be cut off on each side to obtain a true and even surface, the so-called "working inch." The first dressing is done at the quarry, where the block is laid on a low bunker and the larger projections are knocked off with a sledge a (Fig. 22). The surfaces are then dressed with a steel pick b showing parallel strokes. The axe or point c is then used. The axe has a long handle and is used with both hands. The point is struch with the wooden mallet d, or with the hammer in cutting granite.

When the pointing is completed, the surface should be tolerably true in all directions. The top is then laid off in rectangular shape with red chalk, and projections of the edges beyond these lines are knocked off with the sledge. The four edges perpendicular to the wrought surface are then cut and tried with the square, the other surfaces being then dressed from their edges toward their centres. The stone is then called a

rough or pointed ashlar.

The second process in cutting ashlars is dressing the edges of the face with the chisel and mallet, making a so-called draft along the edges with fine parallel strokes, the four drafts forming the margin of the face. The merely pointed surface of the face is dressed with the crandall b to produce a pointed appearance. Only the faces of ashlars are usually crandalled, beds and joints being left pointed. In case of hard stone, granite, syenite, etc., the bush hammer c is used instead of the crandacc, being made entirely of steel with 16 to 40 pyramidal points.

The third operation in dressing stone is droving with the w wide chisel d, held in the left hand like the point and chisel and struck with the mallet. This produces fine lines on the s surface. Sometimes only the drafts are chiselled.

The further smoothing of ashlar is done by finer chiseling; finally the stone is also well polished.

Therefore the modes of preparing ashlars and cut stone in general are; rough hammering, pointing, drafting and crandalling, chiseling and rubbing.

From the method of dressing stone explained here are derived the starting points in the treatment of ashlars, especially of their faces. It is evident that the beds and end joints mu must be pointed sufficiently fine to lie moderately close on each other, thus avoiding the use of too much mortar.

A drafted margin of the ashlar is the simplest mode of cutting to obtain external effect, and is the least that can be a accepted; The panel then receives the treatment suitable for cut stone. As stated in general terms in the Chapter of Tectonics on cut stone as a building material, this treatment depends on the specific peculiarities of the material used, its texture, its conchoidal, slaty or splintery fracture, and the resulting difference in external appearance, so that each material has its proper mode of dressing. Since the chisel used for marginal drafts has a fixed breadth and this is used on l large and small stones, this constant width modifies the effect of the ashlar, making large blocks seem to have narrow drafts while small stones have wide ones. The projection of the central panel varies according to the dimensions of the stone and

purpose to which it is applied. Their projection on the ashlars of the massive Pitti palace in Florence are so great, than one may find shelter from rain beneath them.

This simplest mode of dressing will always be satisfactory when economy of labor is required, as in substructure walls, utilitarian structures, engineering works, fortifications, etc.

The pointing of surfaces is the second mode of treatment; pointed panels on ashlars contrast with those roughly dressed, where a different mode of cutting is desired to express a different and finer quality of masonry. This is especially common in the treatment of the mass of a structure. If the base of a building is of ashlar with rough and strongly projecting bosses, the lower story may be constructed of pointed ashlars.

According to the greater or lesser projection of the bosses, of ashlars and their more or less fine pointing, several grades in appearance of masonry are possible. In both pointed ashlars and those with bosses, drafted margins are necessary to clearly mark the joints of ashlars; on the one hand to give the ashlars a general appearance of having at least received the minimum preparation permissible. If the drafted margiss be entirely omitted, the ashlars lose their characteristic element of form.

Grandalling the surface of the ashlar is but a transition or an intermediate between pointing and droving; it should be entirely excluded from architectural work because not beautiful. Either the stone should be chiseled if the cost is allowable; or if not, it should then be left rough or fine pointed. Bush hammering in case of very hard stones signifies the extreme limit of smoothness usually permissible, especially on engineering works and fortifications. Finally, chiseling is usually the highest limit of preparation possible on fine-grained stones and the best cut stone; The drafted margins almost entirely disappear as the chisel strokes are cut away. The stone is very seldom rubbed, only in case of fine-grained material of good color, capable of receiving a good polish.

In contrast to the ashlars composing the wall in which we use the most diverse modes of treatment to characterize the masonry, it is natural that for moulded or ornamental cut stone the projecting bosses are to be avoided; the best cut mouldings and ornamental blocks being wrought from fine-grained materials as

a rule, for which a finer treatment is suitable; if considerable work can be saved on similar ashlars, this economy entirely disappears in the best cut stone work, since these are seldom duplicated, or one may seex a saving on the ashlars to have more for the ornamental blocks. It is tasteless to form bosses on architectural details.

The Greeks and Romans set stones partly rough dressed and p partly with bosses, after completion of the structure, these bosses were wrought into members and ornaments. Hence many ancient buildings were never finished; for example the temple at Segeste in Sicily, parts of the Coliseum in Rome and the Porta Nigra at Treves.

This mode of building was in part traditionally retained in Romanesque architecture of the 10 th to 13 th centuries. The ashlars and most architectural details were set finished as supplied by the masons' lodges, and only special parts like bases and capitals of columns with many of the more elaborate ornaments of cornices were cut after being set in place.

Consequently many portions of buildings in Romanesque have likewise remained incomplete until the present time. Examples are in the cathedral at Maintz.

During the Gothic period from 13 th to 16 th centuries, the cut stone was always entirely finished in the sheds of the masons, and it was therefore set in a perfect form. The Renaissance masters after the middle of the 15 th century followed t the ancient method in a peculiar way in accordance with their views; since they did not possess a thorough knowledge of classic antiquity, which we owe to many scientific investigations in modern times, and therefore they were unable to correctly explain all appearances, they accepted everything in good faith as found in ancient structures, and employed it in the same way, assuming incomplete work to be perfect and imitationg it. In this is the explanation of many peculiarities of the Renaissance. In future we shall learn to regognize this.

If one desires to build economically and to quickly attain a certain end, he employs for the substructure of a building small or only the most necessary care, so as to devote all his power and artistic skill to the more important parts of the structure; this was also the case for all ancient temples and other structures. The first thing is to place a layer of stones

on a rocky foundation on which the building is to be erected. Gigantic blocks with dimensions even surpassing those of prehistoric stone monuments ascribed to a race of giants, were laid in the courses of the temple terrace at Baalbek, blocks 68 ft. long and 14 ft. high being used; it is easily conceived that the beds were but rough dressed and the margins were drafted, leaving the projecting boss in the state in which it left the quarry, merely removing the greatest projections.

The Romans entered on the heritage from past historical periods, adopting the methods of all predeging races and introducing theg in all countries under their rule; we therefore find this rusticated masonry employed in all Roman structures in Europe and the adjacent parts of the earth.

During the middle ages this masonry with projecting bosses was merely used in fortifications and is generally rare; smooth masonry was preferred in this time. I first reappeared in the 15 th century in the palaces of Florence; it was assumed to have been invented by the Etruscans, ancestors of the Tuscans, and for that reason alone was made a special feature of the Tuscan Renaissance. An attempt was made to harmonize the most diverse modes of cutting the stone with the orders of columns, so as to express by means of ashlar masonry the character of the orders in the treatment of the masses of the buildings, even when without columns or pilasters. This was finally carried so far, that in imitation of unfinished Roman buildings, columns and pilasters were even composed of rectangular or cylindrical ashlars with surface bosses, an error that should n never be imitated at this day. To artificially imitate the imperfect is without meaning.

A special form of this ashlar masonry with bosses appearing in fortifications at the end of the 15 th century is the spherical boss, suggested by the use of artillery; Viollet-le-Duc, in his Dictionnaire d'Architecture, Vol. 2, p. 217, gives an example from the gate tower of the walls of the city of Vezelay, erected under Francis I between 1515 and 1547.

The Renaissance architects invented the so-called diamond p paneled ashlars, i.e., when a drafted margin surrounds a boss with the form of a low pyramid. If the blocks are rectangular this is called a diamond panel, if szuare a nail-head panel.

We give in Fig. 24 an example of this diamond paneled ashlar masonry from a church in Naples, with a second example in Fig. 25 composed of alternating ashlars with diamond panels and with spherical bosses from the olf fort S. Giovanni at Florence. A variation of the motive of this paneled ashlar, which may be required for richer structures as well as for the bases of monuments with the use of polished stones, etc., consists in moulding the margins (Fig. 26) and also in the truncation of the pyramidal bosses. Certain blocks like the corner stones of the base of a monument, the keystone of an arch, etc., should be more richly treated and moulded, but then one must be careful not to approach too closely the forms of joinery.

A decorative treatment of the surface itself of the ashlar, as well as all over refined modes of cutting it is objectionable, as being an expenditure of means in an improper manner; for the same cost at which it is sought to ornament ashlars with all kinds of niceties in the art style of the Barocco period, we may more richly furnish the architecture with decorative or sculptured ornament, or we may employ nobler materials. Yet it should not be forgotten that in purely decorative works like portals, monuments, etc., such a decoration of ashlars by ornamental patterns may be permissible in exceptional cases.

To mould the margins of the surfaces of ashlars leaving the bosses in their rough form is a contradiction, the rough bosses being esthetically justified by poth their bold effect and their economy; yet if the means suffice for moulding the ashlars, it is preferable to change the bosses into diamond panels. Such a contradition would appear like affectation.

The simplest means for causing the joints of the stones to have a bold effect consists either in causing the surfaces of the ashlars to project beyond the face of the wall and form rectangular joints enclosing the surface of each block (Fig. 27, a,b,c,d), or to give the joints a triangular section,sunk in the face of the wall (Fig. 27, e).

The actual structural joint is formed by the bed of the stone in the first case, so that the projecting surfaces of the ashlar protects the structural joint from the penetration of rain. To replace the edges of the projecting surface by chamfers, quarter rounds, coves or mouldings, would greatly increase the

cost of the masonry, but it would also increase the richness of appearance of the joints, and is therefore to be limited to those parts of buildings, in which an increase in expedients is desired as in substructures, accentuation of angles, etc. At the surface of the wall from which the ashlar projects, the joints themselves should not exceed the width of the chisel a and it must be constant; if the effect is too slight for large blocks, the joints can be made wider outwards, their sections being trapezoidal (Fig. 27 a).

Triangular joints usually have a right-angled section when executed in the usual materials; their effect is more marked if their surfaces make an angle of 60° with each other (Fig. 27, a,b,c); when this diedral angle exceedr 90°, they seem broad and also have a weak effect. Fixed rules for the proportions of ashlar joints cannot be given, since their effect must always harmonize with the purpose to which then are applied. Taking the breadth of a chisel as a basis, in case of a richly moulded joint (Fig. 27,a,d), the smaller fillets, chamfers and mouldings must have such dimensions as may be required by the effect of light and shade, and by a varied alternation of proportions of magnitudes.

To treat all ashlar joints as being purely ornamental, where no structural joint is required and not letting the real joint appear, is one of the greatest barbarisms borrowed from the Barocco architecture by modern architects. Architecture disappears with construction; one requires the other, and whoever does not understand how to develop the nature of the former from t the latter, can never place himself beside the mediaeval masters nor yet beside those of the best Renaissance period, who were first of all good monstructors.

The second great barbarism of modern times is to imitate ashlar joints in cement; cement plastering has no limiting dimensions like cut stone, which usually is in courses of 18 to 24 inches high, but its dimensions may be arranged at pleasure; therefore in dividing cement plastering those dimensions and projections should be use, which differ as widely as possible from those of ashlar masonry. Stucco belongs to the plastic and hardening materials, whose treatment should correspond to the means employed in giving it form. The imitation of ashlars

in stucco exactly destroys and falsifies the structural meaning; Whoever becomes accustomed to such forms no longer knows how to use cut stone and transfers to it the formlessness of stucco whenever possible.

In conclusion, it should be remembered that for purely decorative purposes, the arrangement of ashlars in mosaic pattenns with congruent elements is not excluded, on Palladio's famous basilica at Vicenza is to be found such ashlar masonry of marble in scale-like patterns employed on a wall beneath stairs. (Fig. 28).

γ. Ashlar bonds.

The most natural and unconstrained kind of ashlar bond, which is both best and most picturesque, is that in which the stones are cut and set just as obtained in the quarry, without attempting to anrange them in regular courses or to make them of u uniform height.

We give in Fig. 7 a specimen of Greek masonry and add a similar example of Roman masonry in Fig. 29. In case of stones quarried with good beds but ont in long pieces as in porphyry, this random ashlar bond is very appropriate , especially as it is one means op producing economy, also for use in bases and substructures supporting works of all kinds, fortifications, etc.

A transition to regular ashlar bond consists in making the courses of unequal (Fig. 30) or of equal height (Fig. 31) but using stones of different lengths (Figs. 30, 31). Since ashlars are subject to transverse strain, the lower blocks must also be shortest to avoid fracture, and the higher may be longer, but generally the lengths of the blocks should be as supplied by the quarry. The Roman, mediaeval and early Renaissance architects always preferred this natural ashlar masonry, thereby obtaining both an inexpensive and picturesque masonry. The correct principle is to always work in accordance with the materials provided, and so that they may be used for the most diverse purposes, as in case of the normal brick form, predominant from the Roman era until the 16 th century; the High Renaissance first introduced uniformity in the height of courses and in length of stones, which was usual in Grecian temples.

The bond of similar ashlars generally resembles that of brick masonry; the proportional dimensions of ashlars depend on

the materials employed and the height of courses; their length may vary in direct proportion to the strength and height of t the ashlars. The simplest system of construction is that where the stones extend entirely through the wall; then, 1, the courses may vary in height; 2, the length of stones may vary, thus producing the following possible combinations (Fig. 32); a, c courses of equal height with stones of equal lengths; b, courses of equal height with stones of unequal lengths; c, courses of unequal heights with stones of equal lengths; d, courses of unequal heights with stones of unequal lengths.

If a wall consists of square blocks and those with lengths of twice the side of the square, the following bonds are possible 'Fig. 32); e, courses of equal heights with square stones, (Fig. 33); f, courses of unequal heights with square stones; g, courses of equal heights and stones alternately square and oblong; h, courses of unequal heights with stones alternately square and oblong.

If these eight different arrangements are examined, assuming the low courses to have half the height of the high ones, the relative cost of labor on bed and end joints per unit of superficial area of the masonry will be as follows:- a, 48; g, 52; b, 56; c, 63; d, 63; a, 64; h, 73.5; f, 84. For economic reasons then a, b and g are preferable; c, d and e are mort expensive, but equally so; f and h are the most costly of all these bonds. The bonds b and g are most pleasing of those least costly; d is the most pleasing of the more expensive, and e is the most uniform of all the bonds; f and H are dearer and are ugly, but h is that most full of variety though appearing too fanciful to excel the others in producing a pleasing effect by its diversity. These bonds with stones extending through the wall are nearly similar to those composed of separate bond stones, which extend through the entire thickness, and other blocks o only occupying a part of its thickness, usually composed oft two stretchers (Fig. 34, i, k), or a space is left between them and afterwards filled with ordinary masonry (Fig. 34,1). Preference should be given to F 34 k instead of F 34 i, since the wall is entirely built of stones of equal size, and the length of a bond stone is determined by the thickness of the wall, one half this being its side.

It is easy to see that in case of the most commonly employed bond, the greater the number of headers used the more labor a and expense are necessary, though the wall is stronger, hence they are sparingly used, a header being inserted after each t third stretcher in the heading course, two stretchers extending in the stretching course from centre to centre of the headers, so as to give an effect of richness and variety. If the headers are to be made prominent and evident, it will be preferable for sake of economy to finish the stretchers with projecting bosses on their faces, cutting the ends of headers smooth or with diamond panels. The richest of all bonds here mentioned, h, also most expensive, is appropriately used for a royal palace or a any similar building, and if a harder material be used for the lower courses than for those higher, there may be great variety, not only in the form but also in the modes of dressing the stones, if one desires to be consistent to the last degree, the low and long blocks subject to the greater strains should be finished with strongly projecting diamond panels in places most severely strained; the small and less severely compressed headers might be decorated in any way, for example with sunk rosettes if they are of a material easily wrought, or may be cut like precious stones if composed of a hard stone susceptible of a good polish (Fig. 35, n, o). The central lightly loaded large ashlar might have shallow diamond panels, and the large headers could be finished with hemispherical bosses or be treated like precious stones with crystalline recessed angles as in Fig. 25. If such masonry be constructed without headers although the large square blocks appear to be through stones , and they really hold the masonry together, they should have projecting heads like nails or rivets, which may be shaped in accordance with the hardness of the stone or the possible expedients.

The forms of headers may also be improved in the manner employed by Julian Sangallo in the Gondi palace in Florence and as represented by himself (Fig. 36, p, q).

If the masonry is to make a noble yet simple impression, smoothly dressed and polished ashlars of good material will always appear best, and if the best mode of construction is also adopted, the ashlars should extend through the entire thickness

of the wall. This kind of masonry was the normal one in the f finer examples of the Greeks and Romans, and was termed opus isodomum.

With the increasing smoothness of ashlars ending in a polished surface, wie likewise pass to the closest possible fitting together of beds and end joints, so that these entirely disappear if the blocks are very carefully rubbed on each other. If the material be at the same time perfectly homogeneous and its color be exactly uniform, a uniformity of appearance is produced, for which the Greeks did not strive as being the highest ideal of masonry, or they would not have sometimes gilded the joints or have marked them by narrow strips of bronze, which appears an error to archaeologists, enthusiastic lovers of uniformity. It should be stated here that in general ashlar work has entirely renounced the use of square blocks, further that through-stones in very thick walls should have much greater depth and breadth, so as not to be broken at the middle; however a construction like that of Fig. 37 r is admissible, which indicates the thickness of the wall by its higher headers. Very durable stones with good beds, costly stones and those capable of a good polish, are well suited to the so-called plate bond (Fig. 37 s), a peculiar mode of facing walls not without justification in exceptional cases. In veneered masonry b backed by brickwork, rubble or concrete, it is evident that if no through stones are used, the courses of stretchers must alternately extend deeply into the wall (Fig. 38, t).

If labor on ashlar masonry is to be saved, a bond having few headers is not only preferable, but the heights of courses must be as great as possible; but if the material is to be economized as in countries furnishing little stone, there is the choice, either of alternating courses of stone and of brickwork (Fig. 38, u) as very common in upper Italy, Belgium and Holland, or of employing alternate blocks of ashlar and brickwork (Fig. 39,v). This kind of mixed masonry is sometimes found in Belgium and France, and a similar specimen of ashlar and rubble masonry exists in a buttress of the castle of Meissen.

This mixed masonry may be suitable for the brick piers of churches in spite of its small resistance, and it is accordingly found in the churches of Holland and southern Bavaria. The

veneering of walls with elements of different forms is to be considered a fancy, which may be seen or many Renaissance buildings of central France, that are covered by mosaic work of different colors. To this is related the Italian marble incrustations of the mediaeval period, which only comprise the covering principle, and it was a merit of the Renaissance to have developed this into a structural principle.

γ. Expedients for fastening and clamping together ashlars.

Stones are fastened together by means of mortar, as well as by projections of the stones, three specimens of which are given in Fig. 40 as shown in plan, or by dowels of stone or metal, by indenting the blocks into each other (Fig. 41), and finally by cramps. These fastenings are generally concealed in the joints between the stones; if cramps do appear on the external s surface, they are either treated as external anchors set in l lead as in Fig. 42, a, or like Fig. 42, b from the stair balustrade of the bishop's palace at Lucca.

δ. Ashlar masonry in general.

The late Renaissance clearly observed some things that have since been neglected. For example, bed and end joints play different parts; while beds are subject to crushing and offer resistance to it, end joints are not subject to any strain; hence it follows that the beds should be made prominent but not the end joints, and one meets with a twofold conflict, for:- 1, all architectural styles must be cast aside, that have accented b both kinds of joints as in the best Renaissance; 2, the beds must be made most prominent and end joints be subordinated, it would then be inconsistent to leave both kinds unmarked, since ancient and mediaeval architecture would then be rejected. If only beds are accented, the masonry has the appearance of being composed of continuous layers of stone, which is not at all so.

If we consider the masonry as a construction with a right to appear as such, it would be proper to allow it to appear as a structure composed of parts, where the end joints would take their part as well as the beds; this structure may be characterized most simply by the natural mortar joints and does not need to appear as a monolith in order to produce the effect of unity or of a whole, but the power of unity over diversity must be evident in the structure itself.

For the same reason the joints should be accented by means of the expedients already described, and if it is desired to distinguish end joints from beds, which is only proper when it is desirable to make all the fine structural joints evident in the entire building, with the utmost consistency the e end joints may be narrower than the beds and be differently treated.

If we admi the claim of Semper, that regularity of form and similarity of treatment are the supreme requirements for the artistic effect of masonry, on one hand our hands are tied, and on the other the fines structures of the Renaissance are to be cast aside, which owe a good part of their characteristic beauty to irregularity in form and treatment. The same is true of Semper's requirement, that only the substructure as belonging to the earth base, should show the mode of cutting and arrangement of joints, while the structural formation of the superstructure need not be so apparent. We merely have a choice, either to throw aside the Pitti, Strozzi and Rucellai palaces as errors, or of establishing a theory of artby which these s structures may be considered justifiable.

By means of the various modes of cutting already described, the forms of the ashlars and the kinds of bonds, numerous expedients are available for giving the masonry a varied character. From the massive strength of the fortress and the roughness of the rural building to the light grace and princely splendor of the palace, the most varied effects are possible in the appearance of ashlar masonry. The absolute dimensions of the blocks and their proportions add their individual effect to the general appearance of the masonry. Square faced ashlars appear bolder than if oblong, small stones are also bolder if nearly square; on the contrary, large stones are so if oblong.

Increased richness in the external appearance of ashlar masonry may be produced in many ways; either by the mode of cutting, by varying the bond, or by refining the bosses by mouldings, rubbing and polishing, the use of better materials, inlays of finer stone or metals, by decoration of joints, etc.

As for the mode of cutting, all affected and formal treatment of ashlars as if the stones were stuffed cushions, like that originated by the Barocco, is decidedly objectionable. No

attempt should be made to enrich the architecture by increasing the labor in any way, and if it is not desired to economize b but to lavish labor, it is preferable to give the ashlars a d decoration belonging to sculpture.

To accent the bond leads to mosaic work and disguises the s structural character of masonry if carried too far.

On the contrary, if it be desired to retain a rich yet structural bond like Fig. 35, o, and to carry its decoration to the highest point as for an altar chapel, a Santa Casa of Loretto, it is permissible to use a more refined treatment of the bosses by moulding, rubbing and polishing, with nobler materials, inlays of semi-precious stones, noble metals, stone intarsias, decorations of joints by gilding with stamped patterns or mosaics. A memorial or a public fountain would justify the use of this kind of decoration. The corresponding sculptured ornamentation and figure reliefs would require a rich treatment.

It not being possible to surpass this richness in decoration, which is permissible in purely ornamental works, we must then renounce the construction, and either think merely of a covering of sculptured marble, like the facade of the Certosa at P Pavia, or of incrusting the surfaces with polished semi-precious stones with gilded joints and ornamented by stamped patterns, as in the chapel of castle Karlstein near Prague, or lastly of covering the masonry by ornamented plates of bronze or of nobler metals as done in Greece in ancient times.

A peculiar construction of stone walls may be mentioned here, whose principel is entirely correct and admits of great variety of forms, an example of which is found in the Romanesque church of S. James at Regensburg (Fig. 43); the wall consists of stones not extending through its entire thickness, but so arranged that part project in front and part in rear. The panels are e enclosed by an architrave of suitable profile, and the convex patterns on one side become concave on the other. This truly structural motive may be treated in various ways, according to the bond chosen, and thinner and more ornamental enclosing wa walls may thus be employed.

In contrast to ashlar masonry, whose nature is thoroughly structural, bonds imitating ashlar work in structures of wood, Dutch stove tiles, wainscoting, metal work, etc., are to be treated if possible, so that may not remind us of actual ash-lars

ashlars. Sunk panels, entirely inappropriate for stones under compression, more richly profiled enclosing mouldings, etc., are not only allowable for structures of materials other than stone, but on the contrary are to be preferred.

Divisions into ashlars on painted or plastered walls must be treated in a purely decorative manner to appear like tapestries sewed together. Each division should be enclosed within a decorative border, its centre being accented by flowers, rosettes and other ornaments.

2. Brick Masonry.

Brick walls were found in the earliest times among the Assyrians and Chaldeans; they used unburnt bricks general laid with asphalt mortar.

The Romans first developed brickwork; by means of excellent clay and superior mortar and cement they rapidly constructed all kinds of mixed masonry of concrete and of backed rubble, where bricks were chiefly used as a facing for the wall; for this purpose they employed partly triangular and partly rectangular tiles, generally using oblong tiles for through courses of headers and triangular tiles for the facing stretchers, behind which the wall was a mass of concrete composed of cement and fragments of tiles or stone spalls. They preferred opus spicatum as well as a kind of masonry where patterns of all kinds were produced by horizontal bands of color or of colored stones.

During the middle ages brick construction was developed in different ways in various parts of Europe, especially in Italy, southern France, Bavaria, the low plains of north Germany and in Holland. Only north Italy and North Germany created a true brick construction, the other countries having almost exclusively employed a mixture of cut stone and bricks.

A bond was used in Holland during the entire middle ages consisting of alternating courses of stretchers and headers, but the lengths of the bricks did not correspond to their widths, so that a regular breaking of joints was impossible in each second course.

The middle portion of the wall is usually composed of rubble. The natural treatment is to lay alternate courses of stretchers

and of headers, and when the end joints fall together, a longer or shorter brick is selected or is suitably cut. This kind of masonry has the decided advantage of cheapness over all regular bonds, and it is therefore to be recommended as a makeshift. It appears picturesque and less pretentious than regularly bonded masonry.

a. The structural Bonds.

Modern bonds are either those used during the middle ages, like the so-called Gothic or Polish and the So-called Dutch or Flemish bonds, or are those introduced in the Renaissance, as the cross and block bonds.

Ordinary modern brick masonry is composed of bricks of equal dimensions, whose thickness, breadth and length have proportions of 1 : 2 : 4, inclusive of the mortar joint, so that four thicknesses and three joints equal the length of a brick. Bats are sometimes used as well as whole bricks as in Fig. 44; half bricks H, two making the length L, quarters V, three-quarters D, and finally split bricks K, two making the width of a brick. Each brick bond is arranged to that the bricks forming the external face of the wall are laid as stretchers or headers, and upper bricks always cover the joints in the next course beneath.

The thickness of brick walls is always a multiple of the width of a brick, so that brick walls alone are in use, that are 1/2, 1, 1 1/2, 2, 2 1/2 bricks thick. The end joints of the wall face commonly extend through the wall (Fig. 45, a). (Not in U. S). The interior of the wall entirely consists of headers, stretchers being used only on the face. (Not so). If the thickness of the wall equals an even number of half bricks, the courses are similar on front and back (Fig. 45, b); but if uneven, the courses on face and back alternate, a course of headers on one face corresponding to a course of stretchers on the other.

If terra cotta blocks or cut stones are used in brick masonry, their heights must always be multiples of the height of a brick with its mortar joint. These are the most important points relating to brick construction in general.

We shall next consider the bonds of facings of walls, then those at the angles, and will seek the decorative motives resulting from these structural bonds.

a. Block Bond. Fig. 46.

The bond is arranged according to the scheme u u u u u u; the end joints of all stretchers and headers alternate over each other; any vertical element of the wall consists of alternate stretchers and headers. An oblique division of the face has the rhythm - u u - u u, and a vertical one the rhythm + - + - + -. If the bricks are distinguished by different colors (Fig. 47, the bond forms congruent vertical elements a, between which are left interspaces. Used diagonally with bricks of two colors, the bond is changed into a net system. In horizontal and diagonal directions a multitude of decorative pattenrs may be produced by the use of bricks of different colors (Fig.48).

β. Cross Bond.

Like the block bond the cross bond consists of alternate courses of headers and stretchers, but the end joints of stretchers only come in the same vertical in each fourth course and in e each second course of headers. The oblique division of the masonry follows the scheme u u u u , and the vertical one has t the rhythm + + + + + + - -. The entre bond may be regarded as a diagonal net system, whose cross shaped intervals are filled. In vertical, horizontal or diagonal directions, this bond consists of merely abutting courses. It gives rise to the most varied decorative patterns, band-like or net-like motives of all kinds (Fig. 50).

γ. Gothic or Polish Bond. (Fig. 51.

This employs stretchers and headers alternating in each course according to the scheme u - u - u -, a vertical element has the rhythm + - + - + -, the oblique division with the formula - - - - - being entirely composed of lengths. In a vertical direction the bond may be divided into purely congruent linear surface elements, which fit each other without leaving intervals; in a horizontal or vertical direction into detached courses or diagonally into a net system, in which patterns are produced by separate headers as in the patterns of Figs. 51, 52.

Besides the Gothic bond, a variety should be mentioned common in brick construction in north Germany, the so-called Wendish bond, where two stretchess alternate with one header in each course.

These mediaeval and other bonds produce a very rich variety of ornamental surface patterns , which are entirely distinct for each one of them.

δ. Flemish Bond. (Fig. 53).

The Flemish bond is incorrectly termed Dutch bond because it is in common use in Belgium and rare in Holland, conisats of alternating courses of headers and of courses in Gothic bond.

The vertical arrangement of this bond accords with the formula + - + - + -, its oblique division has the rhythm - u u - u u -. The end joints of each second course of stretchers a and of each second course of headers lie over each other. In a vertical direction this bond consists of purely congruent 1 linear surface elements without intervals; horizontally with detached courses, and diagonally of a net system with cross shaped meshes. This bond likewise produces peculiar ornamental patterns. Block bond is the one most commonly and generally employed in masonry.

Cross bond is stronger than block bond on account of the more perfect alternation of the joints. Gothic bond is chiefly used for facings of rubble walls and has less strength than cross bond, and is not as good for facing rubble as a bond composed of stretchers and headers alternating in pairs (Fig. 54), so that two courses together always bond with the backing of the wall. Dutch bond is only ased for walls one brick thick.

The decorations of structural bonds are strictly patterns, that always correspond to those of flat embroidery. According to the old Dutch method still seen in a few buildings, the masonry is decorated by borders and bands of varioss patterns (Fig. 55), which result from the bond itself.

If a bond terminates at the angle of a wall or against an architectural member, it is evident that if it be cut vertically on the lines a b, c d, e f,(Fig. 56) (through end joints of centres of bricks), quarter bats will be required at the angles. In case of the block bond I, the angles will be arranged according to the following rhythm, according to the distance of the left half from the joints a b, c d, e f; denoting quarters by 1, halves by 2, three quarters by 3 and whole bricks by 4; on line a b, 1 4 1 4; on line c d, 2 1 2 1; on e f, 1 2 1 2. The cross bond II gives the following: on line a b, 2 1 2 3 2 1 23; on line c d, 2 3 2 1 2 3; on e f, 1 2 1 4 1 2; it is self evident that the angles should be made as strong as possible, and the use of quarters or split bricks should be avoided at angles;

hence each course commences at the angle with at least halves, quarters and split bricks being placed at some distance from the angle. The bonds in cases I and II are arranged by courses as follows, according to the lines a b, c d and e f:-

	a b	c d	e f
I.	1 2 2 2	2 2 2 2	1 2 2 2
	4 4 4 4	1 4 4 4	2 4 4 4
	1 2 2 2	2 2 2 2	1 2 2 2
	4 4 4 4	1 4 4 4	2 4 4 4
II.			
	2 2 2 2	2 2 2 2	1 2 2 2
	1 4 4 4	3 4 4 4	2 4 4 4
	2 2 2 2	2 2 2 2	1 2 2 2
	3 4 4 4	1 4 4 4	4 4 4 4

Removing the quarters and split bricks from the angles, or replacing them by three quarter bats, the bond will be arranged according to the following scheme:-

	a b	c d	e f
I	3 2 2 2	2 2 2 2	3 2 2 2
	4 4 4 4	3 4 4 4	2 4 4 4
	3 2 2 2	2 2 2 2	3 2 2 2
	4 4 4 4	3 4 4 4	2 4 4 4
II.			
	3 2 2 2	2 2 2 2	3 2 2 2
	4 4 4 4	3 2 4 4	4 2 4 4
	3 2 2 2	2 2 2 2	3 2 2 2
	4 2 4 4	3 4 4 4	4 4 4 4

The peculiarity of this rhythmic scheme is easily explained by the fact that the quarters are not only removed from the angles, but care must be taken to prevent two end joints from coming together in adjacent courses.

Of these bonds only that on line c d is customary. If two walls join at right angles, the principle of the bond will albe that in each course A and B, one wall always extends clear through the other, which abuts against it (Fig. 57, A, B). According to the preceding modes of terminating the bonds, the angles are to be arranged so that there may always be as many three quarter bats at the angle as half bricks in the thicnkess of the wall (Fig. 57), for if but one three quarter were used

at the angle followed by two whole bricks in the header course, the principal rule for bonds would be violated, that the end joints should extend clear through the wall.

If quarters and split bricks were used instead of three quarter bats, the bond would change to the following rhythm, according to the line e f:

Block bond	Cross bond
2 1 2 2	2 1 2 2
4 2 4 4	4 2 4 4
2 1 2 2	2 1 2 2
4 2 4 4	4 4 4 4

The courses alternate in block bond as in Fig. 58. In cross bond the fourth course is as shown in Fig. 59, the others being as in block bond.

The bond varies in the interior of the wall according to whether the thickness of the wall is a multiple of a whole or a half brick, and the principle that each course is continued t through the entire thickness of the wall alternately is not strictly retained in cross bond.

In Gothic and Flemish bonds which are properly used only for facings, it is not difficult to make the rhythm of the bond clear.

Gothic	Wendish	Dutch
4 2 4 2	4 4 2 4 4 2	4 2 4 2
3 4 2 4	3 2 4 4 2 4	3 2 2 2
4 2 4 2	4 4 2 4 4 2	4 2 4 2
3 4 2 4	3 2 4 4 2 4	3 2 2 2

If it is preferred to commence at the angles with three quarter bats instead of halves, it is not difficult to make this change in Gothic and Flemish bonds.

What has already been said in reference to the decorative treatment of ashlar masonry is in part applicable to brick masonry, but from the smallness of its elements this can never give the impression of robust strength, but rather like a network suggests the idea of impenetrability by the intimate connection of its small blocks and its proportionally wide joints.

The decorative expedients of the structural bonds are based upon:- 1, the use of bricks of different colors; 2, the greater prominence of the bond at the angles; 3, the projection and depression of separate bricks and patterns; the thickness of the wall may be indicated by the bond at its angles.

Like the stone wall shown in Fig. 43 from S. James in Regensburg, brick walls may be constructed with raised panels on one side and sunk panels on the other in patterns suited to the b bonds (Fig. 60), especially in 1/2 to 1 1/2 brick enclosing w walls without cutting the bricks. finally, a part of the brick walls executed in patterns may be left open as in parapets, g garden walls, friezes for admission of air and light into ordinary buildings with thin walls.

b. Decorative Bonds.

When the structural principle entirely disappears as in the various panels and ficings of walls, the most varied decorative bonds become possible; they may be used as facings for each constructive bond with the aid of quarters, halves and split bricks, and finally they may be executed with or without the aid of cut or colored bricks.

The simplest form of purely ornamental bond, capable of producing the most varied patterns, is that (Fig. 61) in which e each stretcher is replaced by two halves so that only a single kind of bed appears on the face of the wall.

An entire series of decorative bonds form true wep systems according to whether the bricks are cut or uncut (Fig. 63).

Joints in brickwork are generally so broad (1/8 to 5/8 in.) that their influence on the external appearance of the wall is very decided. In the better kinds of walls they are pointed with strongly hardening mortar or cement, using different profiles according to circumstances (Fig. 64). The modern masonry of Holland is characterized by the use of very small bricks, as well as by having vertical joints not more than 1/8 inch thick while the bed joints are very carefully worded to the p profile d, are 5/8 inch thick, and are always left white.

It has usually been customary in Germany to color the mortar before using it, so that any desired tone of color may be given to the wall in general by means of the color of the bricks and that of the mortar. The bricks are usually of a broken color, dark brown, black, red, yellow, white, with green or violet obtained by glazing. Whoever has an opportunity of comparing the carefully executed masonry of different localities will agree that a white or nearly white network of joints appears best when the bricks are of a dark color. Dark joints are suit-

suitable for very light bricks. The older houses of Amsterdam were built of black or peat-brown, as we call deep reddish-brown bricks, but the joints were always left white. It is undeniable that the aspect of such gloomw houses is made as pleasing as may be possible by the joints.

The imitation of ashlar masonry by brickwork, as exceptionally done in the Italian Renaissance, belongs in the realm of Nonsense.

3. External plastering of Walls. (Stucco).

Since external plastering is a protecting covering for ordinary rubble or for brick masonry, it is to be treated as a covering in the true sense of the word, and its range of form is to be sought entirely independent of masonry. All imitations of ashlar and brickwork,whether painted or in relief, are decidedly objectionable for this reason.

The expedients that may be employed for the decoration of external plastering are those of sculpture and painting. Stucco belongs to form-art as already stated, being a soft and plastic mass.

Therefore stucco work is the proper means of decorating external plastering by a division into panels, the enclosing of panels by mouldings, inserted ornaments in cement or plaster, all ara admissible, but only with the condition that the series of forms may neither imitate those of stone or of wood.

All stamping or incising in the soft mass is well suited to the nature of the material: the inscription or impression of ornaments, a rude treatment of the surface by hatching or by roughening, by sgraffito or by true painting, gold grounds and gilding of various parts, all are adapted to the plaster surface. A painted and symbolical architecture is preferable, which is no imitation but a free play of form cannot be excluded from the domain of plaster decoration.

Plastering serves no monumental purpose in general; therefore it affords a free play for the taste of the period or individual or that due to the subject, but for this reason must be excluded from monumental structures as far as possible.

One of the many barbarisms of the "periwig and pigtail"period, that we adopted and which has not yet disappeared, is the painting of cut stone and brickwork with oil colors. This is

one of the insipidities of the last century, which must be opposed by all means, but we should not forget that the esthetic sense in its lowest stage of development, as in the case of t the general public, sees more art in the cleanness of appearance and in regular and symmetrical arrangement, than in the picturesque; the modern peasant is better pleased by a regular avenue of poplars than by the finest forest, art begins with order and neatness for him as for mankind in general. That he remains at this beginning point, that the great public of cities as well as of entire nations, like the modern Hollanders, can never pass beyond this, one must lament on one hand, but on the other we must consider this love of order and neatness in people as really being esthetic, without which any exaltation to art is generally impossible.

In many cities where the available building materials are scarcely homogeneous, it is often scarcely possible to convince even educated persons, that the natural color of the material, in spite of its irregular and possibly gloomy color, excels a uniform coat of oil color in agreeableness. The reason for this fact is the recognition of order and neatness as a canon of beauty by those persons.

As being important and entirely useful decorations of masonry, we finally have to mention iron wall anchors as well as holders for banners, lanterns, etc., the former being found on almost every old house in Holland, the latter on the palaces of Florence and Siena. Dutch and Tuscan smiths vied with each other in designing tasteful works of this kind, which are to be accepted as true models of a refined treatment of metal.

4. Wooden Walls.

According to construction, wooden walls may be bearing walls like those constructed of horizontal or vertical timbers or of planks, or they may be merely partitions or board walls, palings or picket enclosures, panles or lattices.

α. Walls composed of horizontal timbers.

Such walls are built of round logs or rectangular timbers laid to cross each other at the angles, either with crevices left between them as in the hay barns and sheds od the Alps, or to form walls that are wind and weather proof. The ends of the timbers project beyond the walls at the angles or may

be cut off flush, making the bond visible at the angle.

The decorative expedients for the esthetic treatment of these log walls consist in carving either the joints or surfaces of the timbers. also the projecting ends of the timbers, their bottoms or sides, angles, edges or ends; finally, when the ends do not project the angle bond is itself ornamented. Even if a richer treatment of such walls is found in exceptional cases, these ornamental expedients are always worthy of mention. The true Swiss cottage, Norwegian and Russian churches as well as peasants' houses, which are constructed of horizontal timbers, and finally mediaeval structures of similar kinds employ the most varied forms of carvings in wood.

The carving of the angles of the timbers may be done in various ways, either as mouldings as in Fig. 65,a, or in notches of all forms in repetitions producing patterns of numerous kinds (Fig. 65, b). Carving the surfaces comprises borings and excavations of all kinds, dentils, diamonds, checker-board and zigzag patterns and innumerable sorts of ornaments, with which the surfaces and angles of timbers are enriched. (Fig. 65,c).

One of the best expedients for ornamenting surfaces of timbers is by incised letters, proverbs, etc., or by raising them on a sunk ground.

It is self evident tha the bed joints of the timbers can be profiled so as to be tongued into each other (Fig. 66), as found in Norwegian and Russian buildings, whose walls are required to be absolutely air-tight. the ends of the timbers t then show the form of bed joint. These ends ar free ending a and may be shaped in the most diverse ways by carving their sides and ends (Fig. 67), or by carving them in peculiar forms.

Which one of these modes of ornamentation is to be preferred depends on circumstances, the richness of the decoration, whether the structure is to be an elegant temporary building like a pavilion of an industrial exhibition, or is to be as monumental as possible, and is therefore required to resist strongly the effects of weather; in the last case the choice of forms must be quite limited, since complex carvings afford opportunity for collection of rain water and consequent decay of the wood. Russian wooden architecture sometimes employs timbers of hexagonal and not of oblong section (Fig. 68).

β. Walls composed of vertical timbers.

Such walls are almost entirely used in buildings for ordinary purposes, seldom for those of importance. They consist of timbers set vertically and closely joined together by grooves, tongues, etc. (Fig. 69), usually to prevent admission of water. These timbers are driven into the ground, or their ends are tenoned into sills and plates. The idea of decorating this kind of a wall would never occur to anyone. But if it be desired, the joints between the timbers may be covered by moulded battens, be made visible by carvings, but neither to weaken the timbers or to permit entrance of water.

The timbers should be ornamented by raised ornaments between the battens, and the plates or the horizontal beams tenoned between the ends of the posts should have patterns forming bands.

γ. Board walls.

Board walls are almost entirely used for thin partitions; t they either consist of a framework in which are inserted panels, or of two thicknesses of boards crossing at right or acute angles and nailed together (Fig. 70), or are composed of a single thickness of planks abutting, tongued together or overlapping, with the aid of vertical posts and horizontal girts.

For two thicknesses of boards nailed together it is most tasteful to lap the joints (Fig. 71), as no crack is then caused by shrinkage of the wood, and moulding the joints with a regular spacing of nail heads has a decided influence on the general effect. If this mode of construction is employed for doors, they should be bordered by strips of sheet metal or be completely covered by it, by leather or parchment; doors of mediaeval churches were frequently treated in this way, and the doors od churches and palaces in the Italian Renaissance were sometimes covered by thin metal. The edges of the border strips of metal may be cut in the most varied patterns, nails be changed into rosettes, or their heads be shaped into large and effective knobs; the plate covering may assuem the mediaeval form of horizontal strips, one edge being cut in some form of linear division of the surface (Fig. 72), or be covered by firmly nailed plates as for Renaissance doors, where the nails form a special decorative system, or the whole may be placed under any other arrangement.

Fences or enclosures of boards or planks generally serve merely temporary or necessary purposes, for which an esthetic treatmment is not admissible. If they are to be decorated, it is possible according to the mode of construction:- 1, to mould the joints; 2, to cut the overlapping edges of the boards in patterns (Fig. 73); 3, to cut moulded grooves in the boards themselves in mediaeval style (Fig. 74). The upper and lower margins of detached fences are almost always treated like Figs. 73, 75, which are subject to the general rule that forms are to be avoided, that might cause the projections to break off.

To these board fences should be added the parapets and balustrades of galleries, bridges, etc., as well as paling walls. Balustrades as a whole form bands or friezes composed of vertical elements: these are held together at top by a horizontal rail, their lower ends being tenoned into another rail or held together by a pair of strips (Fig. 76), so that the boards may be cut in free ending forms. This cutting of the boards partly consists in widening the joints (Fig. 75), partly in perforations of the boards (Fig. 76). A correct and healthy feeling l led the nations who most completely developed wooden architecture, Swiss, Tyrolese, Upper Bavarians, Russians and Norwegians, generally to treat the cuts of the boards with rectangular forms like lace and embroidery patterns, or so to form curved cu cuts as merely to indicate a free play of line, avoiding determinate forms of plants and animals. For more than one reason, many of the modern fret-sawed forms of our wooden architecture are therefore objectionable, since they imitate outlines of objects in an unsuitable material, that may be painted on but not fret-sawed in boards, and further is is forgotten in the first place, that these cuttings depend on a finely balanced division of the parts removed and left, but never on the repetition of any definite thing.

Only in exceptional cases, wooden brackets, acroterias and similar architectural details are cuttings in wood to be used, which represent heads, animals and plant forms, ornamental objects generally with curved lines, and they are then to be treated with exceptional delicacy. This requirement for wooden architecture is easily justified. The fibres should be cut as little as possible, or at least ont in such a way that parts

of these wooden decorations may drop off; the wood should also form a coherent net system. If it be desired to saw anw ornament in a board similar to that painted on by means of a stencil, the fibres are not only improperly cut, but the very refinements in the movement of the ornament, the leaf points and the smallerforms are sawed out with difficulty or incorrectly, as the thickness of the board hinders the free management of the saw. These complex forms of fretsaw designs are only suitable for sheet metal or verw thin boards, scarcely employed in wooden architecture.

The sawed out ornaments appear dark or light as a rule and are perforations sunk like black spots on a light ground; they attract attention more strongly than the wood and therefore r require form treatment before all else; if it is possible so to shape the perforations that the remaining woodwork assumes proper forms, it is self evident that this is to be preferred. Exactly the opposite or what is here said is true of carvings on boards not cut through; in such cases one has perfect liberty to do as desired. If perforated boards are nailed on other boards to form a kind of decoration in relief, from the fact that the perforated board must always form a net system, the same freedom is permissible as in case of imperforate carvings, since the more fragile portions are firmly nailed. The finest Swiss houses and wooden houses in the Tyrol and upper Bavaria have adhered to this primary law with great consistency; the perforations are almost entirely openings of pleasing shape and arrangement, but the free ornament is used on friezes, panels and similar ornamental portions in the form of a board nailed on. It is self evident that either the perforated or the board nailed on may be carved to obtain a sculptured effect, or it may be decorated by the aid of painting. But from this is to be rigidly excluded one expedient of the poverty of modern thought, though it always passes for a mode of i increasing the beauty in spite of its ugliness, the chamfering of angles and the outlining of forms by a colored line. It is incomprehensible that this error in taste does not disappear, but in our schools it is even prized as a specimen of refined taste. The most pleasing form is afterwards weakened and ruinet at an increased cost, and if it is to be made especially

beautiful, a bold red stripe is then drawn at a uniform distance from the ugly edge, so that the form possesses still less character. Is the architect then compelled to ape the wood carver, who alone possesses the right of enclosing has work by bands?

δ. Paling walls.

Paling walls also include simple park fences consisting of vertical poles placed close together and supported by horizontal rails, and they present different modes of treatment. The fences mentioned possess means of obtaining the most diverse forms, in the careful selection of pickets of equal or alternately equal diameters, in the substitution of pleasingly interwoven willow twigs for the horizontal rails, in the simple carving of the upper ends of the verticals and in the partial removal of their bark. For park enclosures, poultry yards, fences in zoological gardens, etc., this simple motive admits of variation in many pleasing ways, and if the woodwork, whose principal color effect is due to the color of the bark and the wood of the denuded places, be heightened by the aid of interwoven work of brightly colored twigs, Indian red being used on portions of the poles, and the openings between verticals being filled with fine lattices, as may be required, from these simple elementary ideas may be developed an inexhaustible wealth of treatment of forms.

A peculiar use of paling work is found in Upper Austria and Steiermark in hay sheds and similar rural structures for ordinary purposes; the simple frame of such sheds is so filled in with slender fir poles as to make the spaces between posts, girts and plates appear striped (Fig. 77), these stripes are formed of the poles and the spaces between them and may be varied in many ways. This kind of a wall has recently been employed for rural structures and zoological gardens, etc. Ordinary lattice partitions are used in all kinds of buildings for ordinary purposes and are treated in many ways by means of cutting the edges of the strips. From the method of dinear division of surfaces an inexhaustible number of motives may be obtained, which are evidently governed by the same limiting principles, that have already been given for the ornamental cutting of boards (Fig. 78).

From a higher point of view the forms of the strips may employ every expedient of carving, and may thereby be changed into works of low relief in wood carving proper; also the round pieces furnished by natural trunks may by the same expedient of carving be transformed into true sculptures in wood.

ε. Paneling and lattices.

Paneling is always composed of a thicker framework with thinner panels; the frame forms a kind of network and the panels may be grooved in, fastened on as a lining, or may be entirely omitted. The material of the panels is usually wood, which may be replaced by marble slabs, plates of engraved or cast metal, sheets of glass, parchment or colth, etc., according to the p purpose served by the paneling. We now have to consider in detail the modes of forming the framework and construction of the panels, simple panels, materials of panels, treatment of joints, mouldings, etc., the various kinds of lattices, and lastly the purposes for which paneling and lattices are used.

Paneling is constructed of small pieces of wood by placing one series against the face of the other, by mortises and tenons, tongues and grooves, etc.; strictly speaking any net system may be employed for paneling, but preferably only a web system, some mosaic or lattice systems are made a basis of paneling. The essential requirement for the pieces of wood used in the framework is that they must be narrow, so as to shrink but little. Therefore they should be rather narrow than wide; the same is likewise true of all wooden panels, which shrink least the nasrower they are. From this results a division of the framework into many combined elements; when the frame is to be made very broad with narrow panels, solid tongued and grooved mouldings must be placed between the frame and the panels (Figs. 79, 80).

The decoration of the framework itself must accord with the principles established for the bordering or enclosures of surfaces. It is usually moulded and decorated by inlaid or carved ornaments, and is also ornamented by metallic knobs placed at the intersections of the wooden pieces or by metallic trimmings.

The richest paneling is to be found in the joinery and cabinet work of the Arabs, and in that of the Renaissance.

If the panels each consist of several parts, they may be combined in accordance with any suitable mosaic system (Fig. 81); they then generally require to be strengthened by a second thickness of boards at right angles to the panel. The panel may also be composed of two thicknesses of elements, these in front covering the joints of those in rear (Fig. 82), a favorite motive in mediaeval work. Finally, the panels may be partly or entirely replaced by mouldings grooved in, or special rails a and muntins may be inserted, the grooved-in mouldings being broken around between them (Fig. 83). The wooden doors and ceilings of the Italian Renaissance employed these motives in very varied ways; the use of grooved-in mouldings and special rails and muntins affords this advantage, that finer kinds of woods can be used, which are not of large dimensions, and that the paneling appears both rich and strong; on the other hand both labor and cost are increased.

Joinery of the present time employs less than it might, kinds of materials other than wood for panels in paneling. Wood is always necessarily used for panels, when these are subject to direct strain as in doors, wainscot and similar works, where they may be broken or pressed in. To increase the direct strength, its middle portion should be strengthened, either by the mediaeval vertically moulded and raised panels, stopped at their upper and lower ends by carvings of many forms, or by the Renaissance raised diamong paneled ashlars, but one must be as careful as possible to keed the forms of these diamond panels as distinct as possible from those employed in stone work.

To this use of the ordinary woods for panels may be added that of the precious woods, of intarsias and all kinds of inlaid work. One of the best materials for the panels not exposed to injury is smooth stone of fine color and polish, easily procured in many localities. Not only the different kinds of marble, but also the various kinds of quartz, serpentine, lapis lazuli and fluor spar, etc., also glass crystals and stained glass, can be employed as panels, with slabs of engraved slate, etched lithographic stones, or any other suitable natural or artificial minerals, true sculptures, reliefs, etc.

We may further use for panels plates in relief of cast, hammered or electro deposited metal, enameled plaques, etc., the

products of metal and art industries, faience and majolica, p porcelain and glass, the latter being transparent, with decorations engraved or etched, staned, gilded or opaque glass in t the form of mirrors· also parchment, stamped leather, silk, v velvet, cloth, lace, gold brocade, embroidery and other textile materials, lastly paintings executed on canvas or other materials.

The parts of the frame are connected by joints at right, acute or obtuse angles, and are corners, cross or intersecting pieces, and during the middle ages it was the rule to ornament the insets and mostised joints in some way (Fig. 85). This is especially true of common wooden doors, which were ornamented in the simplest way; these decorated joints, such as are found in mediaeval and Swiss houses are worthy of use at this time.

The treatment of joints between panels and framework results from the requirement that thepanel shall not be loosely set in the framing, bu so as to freely expand and contract without danger of cracking or warping; if the panels are made of ordinary wood as usually the case, and that readily shrinks, two conditions are established, that the woodword must not be painted, since a line joint of a different color would become visible by the shrinkage of the panel, and that the joint must be covered so that expansion and contraction of the panel may not be visible. This may be done by moulding the edge of the framework and placing a round next the panel; or by fastening a round or moulding of wood or metal to the edge of the framework (Fig. 86). If the wood is merely left in its natural color, only being oiled or coated with transparent varnish, t the joints will not be visible, and the rounds anf mouldings will not be necessary. If it be desired to paint the woodwork, with a fpreference for unpainted mouldings and joints, only t the surfaces of the framework and panels are painted, leaving the mouldings in the natural color of the wood.

The mouldings of the framework and panels are determined by the following considerations; they are struck with a plane, a great variety of forms being thus possible; if the paneling is employed in the interior of a building, and is thrrefore principally lighted by diffused light, a strong movement in the profiles is required, while a moderate one suffices for exteriors.

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The darker the woodwork and the more distant it is from the e eye, the stronger must be the movement of the profiles; polished woods and shining paint, varnish and gilding, are suited by the weakest movement.

According to the view with which the framework is to be arranged, that the material may appear more prominent around the margin of the surface or recede from a nucleus, leaving the middle less prominent (compare Tectonics, p. 195},state ments concerning limiting forms), with the other view that concavity is connected with the representation of attraction and convexity with that of repulsion, determine the profiles of the pieces forming the framework, in connection with the principles previously stated.

Not taking any special style or the ancient orders as a basis, but in accordance with the preceding views, the profiles of the framework and mouldings may be composed of simple forms of section, which must be employed by men under all conditions in which they are placed. These simple sections are (Fig. 37):- 1, chamfering the angles. 2, rounding off angles; 3, hollows; 4, combined rounds and hollows; 5, combined hollows and rounds; 6, rounds; 7, grooves; 8, combined rounds and coves.

Variations of these basal forms may occur in three ways; a, by a more or less strong curvature of the profile; b, in case of combined forms, one or the other or neither is most prominent; c, when the form is not only treated as a connected but also as a transitional form, as in case of a curvature varying from a circle. Fillets, grooves and small hollows, serve to s separate the different members, at the same time being bands to connect them; the plain flat surfaces adjoining these members serve as a contrast to the mouldings.

If it is asked how the historical styles of architecture have actually treated these moulded members, the answer readily follows, that they could not invent them as ground forms or geometrical conceptions, and could not separate them from the associations with which those forms are connected. Thus they only had a choice of omitting the ground forms on one place or of concentrating them on another, as in ancient classic architecture where the cavetto and round were seldom used, or as in Gothic where most members were composed of these two forms.

and further divide the half-timber work into smaller panels.

In our modern times it is customary to make this work as regular in form as possible, using only straight timbers and thereby sacrificing the advantage of variety in effect and obtaining scarcely any improvement in the more perfect and stronger construction, which remains approximately equal to timber work regularly arranged as in Fig. 101, or irregularly as in Fig. 102.

Half-timber work plays its most important part in the construction of trusses and then in the construction of timber girders of bridges.

The motives for the esthetic treatment of half-timber work result from the form and arrangement of the timbers, from the mode of their intersection, as well as from the mode of filling the interspaces.

The half-timbers may be arranged in various ways as we have seen, and a difference should be made by the use of regular or irregular panels and their braces and girts, according to whether the purpose be structural or ornamental. Pugin gives in his Details of ancient Wooden Houses the examples of half-timber work represented in Fig. 103, as existing in houses at Boulogne. An alternation of different arrangements of the panels will always have a more pleasing effect, than if they were all treated in exactly the same way. The most pleasing half-timber houses have been preserved in the peasant villages and small cities of those countries in which wooden construction has been preferred; they frequently exhibit very instructive details, and are evidence of a true art feeling in their builders. for example the houses of Switzerland and southern Bavaria, of the Tyrol, the wooden houses of Swabia, of the Rhine provinces, of Hesse, of France, those of Norway, England, etc.

The use of naturally or artificially curved timbers in wood constructiou, or those cut into curved forms, may be very ancient; these were unjustly discarded from half-timber work in our tome. The middle ages, the wooden architecture of the Tyrol and upper Bavaria, as well as that of Switzerland, favored the use of this means of obtaining pleasing forms in their half-timber work.

A few examples of such forms are here added as illustrations

from the houses of Hessian peasants (Fig. 104).

If the faces of the timbers are to be decorated, the struts being subject to compression are to be decorated by incised or painted stripes lengthwise like supports, and their ornaments may end in volutes, but the girts being in tension are to be characterized by patterns like bands.

The intersections of the timbers can be decorated in the manner described for paneling, and which was common in mediaeval and Swiss wooden architecture (Fig. 104, right).

The spaces of half-timber work are either filled by a covering of boards, which is most pleasing if placed on the inside of the wall, or by unplastered brickwork, for which a purely ornamental bond is especially appropriate, or lastly by plastered masonry. This plastering may then be ornamented in any of the ways already mentioned in the Chapter on its use, such as by incised sketches, sgraffito, ornaments in relief,or paintings. Half-timber work of special elegance is filled by tiles or terra cotta plaques.

In addition to a consideration of the structure of walls, we still have to mention covering the walls with slates, shingles, tiles, etc.

The mosaic system is the basis of all these modes of covering walls, and manifold motives may be derived from the linear division of surfaces with congruent elements as in Fig. 105..

E. CEILINGS.

1. Non-vaulted stone ceilings.

The ideal of ancient architecture was the construction of stone ceilings with beams and slabs of stone, but it has lost nearly all practical value for our time. But the stone beam ceilings have retained a symbolical value for us. If we place ourselves on a purely material standpoint, and recognize or mentally perceive only what serves a material purpose, if we strip away every historical reminiscence and allow no custom or usage of past times to be correct, we should then throw the stone beam ceiling into the historical lumber room, for me may attain the desired end better and more cheaply by means of vaults or by iron construction.

But if we place ourselves on the general point of mankind, where we must know how correctly to distinguish between what

has but a temporary historical justification and what has a p permanent value for all time, we shall find that in spite of differences of race, language and people, mankind is not only a unit in its mode of thought, but has symbolically retained remembrances of modes of life lying far behind us, and employs them on special occasions as in memorial ceremonies or monuments. In Tectonics in explaining the relations of form and purpose, we carried this thought farther and illustrated it by a few pertinent examples. We shall here call attention to the fact that objects become purely symbolical, when their original purpose no longer exists, as in the case of the hammer and trowel in laying corner stones, a ship used as a table ornament or gift of honor; that uses become symbolical, like the production of fire by rubbing together pieces of hard and soft w wood in the ceremonies of nations, that have long made use of flint, steel and tinder.

We therefore still have a right to employ stone ceilings for ideal purposes, even if we could attain the end more economically by other means, and could cover the area by vaults, especially in case of tombs, mausoleums, churches and art museums; it is self evidentthat such use of stone beams is only possible when permitted by the narrowness of the roogs. But a second p principle naturally follows, recognized in Tectonics in the true sense of the word, that stone beam ceilings must not be imitated in wood or other material, when the use of stone becomes impossible for static or pecuniary reasons. A false or bad symbolism like that introduced by the Neo-Grecians and never used by an artistically sound people consists in the external imitation of a thing, but a true symbolism can only result from the repeated use of similar means under similarly limiting conditions. If we can use granite with a resistance to fracture greater than that of marble, wider rooms may be covered by stone ceilings, than those found in the monuments of classic antiquity; if we place light plates of glass or metal on these beams instead of heavy stone slabs, we shall be enabled to cover still wider spans. If a ceiling is constructed of wooden or iron beams, the spaces of the ceiling would n not be filled by slabs of marble. Briefly we can take scarcely any course leading us in a rational and free manner to forms,

suitable for stone ceilings different from that pursued by the ancients.

If we now place ourselves on a purely material standpoint, the motive employed in the construction of stone ceilings may be derived from the problem itself. If the space between two stone beams or two walls is to be covered, the method first suggested is to cover it with a single stone (Fig. 106). To shed rain water we incline its top toward two or four sides, and since it is less easily broken when its weight is reduced, we may hollow out its under surface. The largest ceiling stone ever yet employed is that of the tomb of Theodoric at Ravenna, which has the form of a low dome about 32.8 ft. diameter.

If the span between the two supports, whether stone beams, walls or rocks, is too great to be covered by a single stone, it is simplest to place several stones side by side (Fig. 107). The grandest use made of this simple structural principle is in the bridge of Loyang in China, which crosses an arm of the sea by 300 openings, each being about 46 ft. wide in the clear; 7 beams of black marble are laid from each pier to the next, and on the ends of each pier are placed marble monsters, those at one side resembling lions.

The problem may be solved in another way according to whether the abutments are stable or not. If they are, the simplest mode is to place two stones against each other or to arrange them in an arched form (Fig. 108), with the condition that they must not slip on the abutments. In general we may designate t these and similar modes of constructing ceilings employed by Egyptians, Etruscans and Assyrians, as preclassical structural methods. To these is allied the widely employed principle of corbelling used in structures, whose supports are unable to resist a thrust. Beams of stone are alid so as to project beyond each other in an inverted pyramidal form, the span being thus reduced until the opening at top can be covered by a single stone (Fig. 109).

This principle from the earliest times to the present day w was restricted to all ceilings of stone where an increased height was permissible; its highest development occurred in the the stone broach spires of the Romanesque and Gothic styles.

The simplest form of corbelling is produced by a single pro-

projecting courseon which is laid a covering slab (Fig. 110); in case of covering wider spans or a greater height of ceiling several such courses become necessary, projecting more in the first and less in the second case. The corbels may be formed in a great variety of ways, either by partly or entirely beveling them as in Fig. 110, or they may be shaped as supporting parts with convex profile forms occupying more space, with transitional concave forms,or be decorated by cymatiums and rounds (Fig. 111). The architecture of different nations employed in these corbelled ceilings, sometimes simple beveled corbels, sometimes one or the other profile form, or sometimes a combiantion of members. According to the purpose and the problem, one may also employ these simple decorative expedients at this time, provided that all the forms are generally acceptable, and ase such as result from the problem itself, none merely b belonging to any special style. It is senseless to refuse to use them merely because any architectural style first employed or extensively used them.

Corbels (Fig. 112) as separate bearers, employed as modillions in classic armhitecture, or in the middle ages as supports for the most varied purposes, are nothing else than such a mode of constructing ceilings in another form; for if the ceiling itself only slightly preponderates in comparison with its mode of support, or if it assumes any form, the principel remains the same.

From the need of reducing the height of the stone beam ceiling consthucted by corbelling, the classic coffered ceiling t takes its rise. The architrave is the principal support of the ceiling and extends along the walls and above the columns, usually composed of two deep beams set side by side, one outer beam passing the other at the angle, which abuts against it, while the two inner beams are mitred together (Fig. 113). The stone beams form a great paneling showing large openings on i its plan, and these may be covered by any methods previously mentioned. The classic coffered ceiling (Fig. 114) divides these large openings into smaller ones by a series of beams A A, and into a second series of still smaller panels by a second series B B of still smaller beams, then covering the spaces by a number of stone slabs, excavated in the form of coffers

to lessen their weight. The beams A and B together have a certain depth that corresponds to that of the height of the geison or projecting part of the cornice (Figs. 114, 115), and it is so arranged that this is supported by B and also rests on the architrave, either as in the Doric style by a series of low pillars, the so-called triglyphs whose intervals are filled by the stone slabs of the metopes, or in the Ionic and Corinthian orders on the stone beam of the frieze. In the Ionic style the intervals between the beams are sometimes materially reduced by corbelling out the beams A and B, a third series of beams C sometimes being inserted, upon which are then laid the coffers.

So far as our knowledge of ancient architecture extends, we cannot assert that the ceiling of stone slabs was developed in its full extent. There are still possible solutions of the problem not employed in the classic styles, or at least no examples of them have remained to us. It is first to be considered that larger interspaces between the stone beams may be covered by stone slabs laid against each other instead of coffers (Fig. 117); The slight thrust exerted by such panels may be e entirely neutralized by anchors of metal. Further the principle of corbelling may be employed in a more extended way than in the classic styles, and finally it is not necessary to make the coffers themselves square, but they might as well be hexagonal or octagonal, when stones of suitable form are placed to support them (Fig. 118).

If the principle be consistently executed, that the construction should supply the leading ideas for the architectural treatment, one may then use the classic beam construction at the present time with perfect impunity, the Ionic frieze as well as the Doric triglyphs and metopes; but for the same reason, one should not regard the triglyphs as being purely ornamental expedients like the Roman and Renaissance masters, and retain them when the frieze is composed of continuous blocks. The triglyphs are and remain supports, although perhaps originally used in another sense, the metopes are panels, and neither has any justification for its existence if it supports nothing or fills no interspace.

To declare the architrave unnecessary, when it does not span

the intercolumniations of columns or pillars but rests on continuous walls, like most of the Gothicists and the Rigorists for false Tectonic aims is no less a mistake, which could only proceed from the erroneous idea, that the wall is to be regarded merely as a space enclosing member, but not a supporting one also. Wheu the wall acts as a support, it must be regarded as a kind of extended pillar. The masonry, even when most perfect, requires a leveling course to support the parts that commence above it, and the architrave is very justly regarded as acting as such a leveling course when it does not span openings. But since this would have triglyphs with greater propriety than the free spanning architrave, whose middle should be as lightly loaded as possible, the latter should be constructed in accordance with the principle of reducing the weight, as in the temple of Jupiter Stator at Rome (Fig. 119).

That the classic styles employed the principle of corbelling in the construction of the richer forms of ceilings is proved by a beautiful example, the tomb at Mylassa. The motive of this ceiling (Figs. 120, 121) exhibits a rich alternation of different forms of stone beams and coffers.

If we now inquire concerning the esthetic treatment of all these constructions, we shall scarcely attain any result other than that reached by the classic styles and accepted by the Renaissance; On the one hand that the beams are always bearers, on the other that they connect the supports with each other and with the wall. To increase their direct strength, their depth should exceed their width. Their lower surfaces are appropriately ornamented by band patterns and imitations of twisted ropes that express connection; supporting moulded members are suitable for their upper edges as in the classic method, which are decorated by leaf patterns and pearl beads.

Their mouldinms will have different profiles according to t their materials and the mode of lighting, the light almost entirely coming from beneath in case of ceilings, through windows and as reflections from the floor in case the coffers are not made of glass.

The following distinctions concerning the forms of ceilings are to be considered.

If the moulding and beam form a single piece, much material must usually be cut away from the rough block. Hence in the

construction of ceilings on a very large scale, it is preferable to insert the mouldings as separate pieces in the beams as at a (Fig. 122). If the principle of corbelling is to be utilized as much as possible, we should let the moulding predominate as at b (Fig. 122), subordinating the vertical surfaces; according to the end proposed, the profile will itself be varied, either choosing the energetic convex form, or the softer concave transition form in case of lighter constructions. If the stone beams are all properly anchored together, or their ends are built into loaded masonry, when the architrave should not be too heavily loaded, and when the span is small and deep architraves of strong stone are used, a strong projection of the corbellings is permissible; it is then best to mould the entire surface of the corbelled beams, since their centres of gravity are then removed farther back from their faces as at a (Fig. 123), while with the arrangement b, the projection of the overhanging part of the beam makes it possible for it to tip over. If the beam a (Fig. 124) is so long that it has a firm support at each end, it evidently may be corbelled out considerably; but the intermediate beams b, which complete the framework, must then either be corbelled out but little, or they must be supported by the ends of the beams a a by means of inclined joints. This horizontal lower surface of these beams may also be decorated by patterns like bands.

In mediaeval stone beam ceilings, the angles of the beams a are generally moulded by coves and rounds (Fig. 125). Scarcely can anything be urged against this practice, yet one should adhere to this rule, that all approximations toward mediaeval forms should be avoided, the further the work is removed from the construction of churches, but these forms become permissible in the ratio on which the work approaches that purpose. A Renaissance like that desired by us and which will satisfy all requirements of our time, may very properly approach more or less closely to one or the other style tendency , or even the styles of foreign nations according to its needs, without losing its internal unity so long as it adheres to a principle t that is generally applicable; but this principle must be that nothing is imitated, but that the form treatment is developed from the thing itself, and with this thing are always connected

the purpose and the material, the construction, the external requirements of life and the local conditions. But we shall return to our theory of form after these general consideratiens.

The vertical side surfaces of the stone beams are not usually decorated; yet they might be ornamented by a so-called fret, the well known Grecian band ornament, or by a band of palm ornaments.

The coffers themselves are stone slabs hollowed for sake of greater lightness, and were treated in the classci styles as if transparent, just as if the starry sky was seen through them, ard they were therefore decorated by golden stars on a ground colored blue or red. At a later date the stars were changed to rosettes in relief.

These ornamental expedients for the treatment of stone ceilings have a claim to be employed again when stone ceilings are used, by being both pleasing and characteristic as well as a venerable form motive consecrated by tradition.

If it is desired to close the interspaces by several slabs joined together, rather than by coffers (Fig. 126), they should be made lighter by being hollowed, the joints being concealed by rounds or pearl beads, the whole being crowned by a decorated keystone. The coffer might also be wrought from a thick block instead of a thin slab, and be lightened by being hollowed and by removal of the superfluous stone on its exterior, a and decorated by a suspended flower (Fig. 127).

2. The ceiling of Wooden Beams.

The simplest form of wooden beam ceiling is that composed of a series of beams on which is laid a covering of boards (Fig. 128), this floor may be for walking on or it may be loaded, a and in the last case the beams must be so strong and placed so near together, that they can support the load. If the span is too great for the beams to support the load without bending, they are supported by girders at their centres, or by several at suitable distances (Fig. 129). These girders may in turn be supported by trussed beams and by vertical posts as shown in Fig. 130, where several different forms of trussed beams are collected in a single figure, employed in the construction of mediaeval ceilings in Tübirgen and its vicinity. In Figs.131, 132 and 133 are shown further examples of similar modes of

supporting beams by cap pieces from the town halls of Freiberg, Meissen, and the Gernanic Museum at Nuremburg. The bead ceilings may be so constructed as to have intermediate beams (Fig.. 134), and the main beams may be doubled or trebled instead of being supported by girders, so as to support the load, further the board floor may not be visible from beneath, the interspaces being filled by separate panels of boards.

It is now easy to derive from the structural idea the motive which supplies the decoration.

We first have to consider the beams and their supports, their bottom and side surfaces; we shall then speak of their connections with girders, caps, trussed beams, the entermediate beams, doubled and trebled beams, lastly of the board panels, their joints and border mouldings, and the grooved-in panels.

If the ceilings are not supported but are suspended from the roof construction, the suspension members and rods, the trussing of the beams by iron, should all be mentioned. From the motive of the suspended ceiling may be derived peculiar forms, like those favorites during the middle ages and taking the form of vaults, although constructed of timbers. In all wooden structures the supports of the ends of beams are of great importance, for if the ends of the beams decay, the ceiling falls.

These end supports of the beams vary according to the purpose of the timber work and its arrangement; either the ends of the beams form wood corbellings in wooden and half-timber walls, which support the upper stories (Fig. 135 a), or their ends are flush with the external surface (Fig. 135 b), or they rest on a wall plate or girt like the beams of a wooden roof (Fig. 135 c), their ends are built into the wall (Fig. 135 d), or t tenoned into a wall beam according to a French method (Fig. 1 135 e), or laid on a bric corbelled cornice (Fig. 135 f), or a wall plate is inserted between the beams and the cornice (Fig. 135 g), or corbels are used instead of a cornice (Fig. 135 h); with posts placed between the corbels and wall plate in many cases with or without brackets, or finally the wall plate rests on a projection of the wall.

In all cases where the end support of the beam forms an offset, so that in interval exists between the support and the board floor, this may be filled with a vertical board or by

one inclined forward (Fig. 135 i); if this board may be decorated by perforations, and the joints between it and the board floor be concealed by moulded strips. The wall plates may be moulded, decorated by stripes lengthwise or be left smooth.

The most pleasing forms of end supports are derived from the motives f, g and h when the cornices of stone or brick are of rich forms or by the development of the corbels. Very rich methods of constructing these end supports were devised in the middle ages and during the Renaissance in numerous massive wooden ceilings of Dutch churches, town halls and castle halls, etc.; their principle is to lessen the spans of the beams by beans of long caps. A corbel a (Fig. 136) supports a strut b on which rest two caps c and d, which support the beam e. The cap c is supported by a brace i, a wall beam by the braces h,, and this wall beam serves to receive the board floor laid on the beams f. The corbels are shaped like classic consoles, or are decorated by shields, heads or figure sculptures, the caps may be characterized in the most varied ways, as being both free ending and supporting members, for which the volute curve derived from the Ionic capital supplies a suitable motive; the struts are generally cut from crooked timbers and are curved in various ways; finally, the struts and beams are moulded or decorated otherwise; massive pins with carved heads in suitable locations increase the pleasing appearance of such ceilings.

An example of a beautifully carved cap is given in Fig. 137, from Burghausen near Oetting in Bavaria.

The intervals between the beams e and f may be filled with perforated, carved or smooth boards.

The lower surfaces of the beams are appropriately decorated by band patterns of carving or painting, and the side surfaces by frets, bands of palm ornaments, etc., borrowed from stone beam ceilings. But the most suitable mode is to mould the angles and surfaces of the beams. Since these mouldings are produced by a plane, they either extend the entire length or terminate at the middle and ends against special carved ornaments. a fine example of this kind is shown in a curved beam ceiling of low rise in Zurich (Fig. 138).

Girders are to be treated like the beams. For trussed beams, four examples are given from in and around Tübingen, the form

of an elastic spring may be generally recommended, as seen in the bow and crossbow and in the related form of the Ionic capital, a form whose nature and function fully correspond to that of the trussed girder.

In case of the intermediate beams we are governed by the thought, that as these are less heavily loaded than the main beams, they should express the character of this loading. The ground idea of the moulded beam, whether main or intermediate, is alwas that of a bundle of pieces bound together and resisting the flexure of the beam; rounds, coves, fillets and grooves as well as chamfers, alternate with each other in rich variety. In this way are produced the mouldings of double or triple beams by the combination of the half sections of the separate beams of the different layers. Figs. 139, 140, give examples of beam ceilings and sections of beams from castle Chillon. F Figs. 141, 142 are from the castle of Meissen; fig. 143 is from castle Schaefenburg near Dresden; Fig. 144 from the Nicolai c chapel in Dippoldiswälde near Dresden, the two last being in the Renaissance style.

The rules already given for similar cases apply to the board panels, the joints may be matched or rebated and beaded, so t that no apparent crack resuêts from shrinkage of the boards. the joints may also be covered by battens fastened to the boards at one edge only, so that the adjacent board may freely expand and contract.

The inserted panels should be enclosed by mouldings and may be left plain, carved or perforated. It is easy to see that by partial painting and gilding, the éffect of such ceilings may be materially heightened, and in case of necessity a pleasing effect can be obtained by the colors white, black, yellow ochre and IÑdian red. But it should be considered that in ceilings with moulded beams, similar members must have the same color, that gold should only be used for fine lines, and that the members should be sharply separated by narrow fillets and grooves, etc., so that the colors may be used on spaces that are moderately lighted. The farther the ceiling is from the eye of the observer and the less strongly the room is lighted, the brighter must be the colors, so as to have a good general effect. On the same grounds the painting of objects in gay and bright col-

colors may be censuredas in case of the furniture of churches, etc., viewed from a small distance, as an error of taste, that has become quite fashionable with many architects during a very recent period.

Different decorative forms result from the construction of suspended ceilings where the points of intersection of the beams require special consideration. Id the suspension members are iron rods with screw ends on which nuts are placed, a washer must be inserted between the nut and beam. This washer may take the form of a rich iron ornament, or may be replaced by several disks of metal placed on each other, or by suspended ornaments like chandeliers. The latter are particularly appropriate when chandeliers are to be suspended from the points of intersection.

We have already stated that turned constructions may be used to divide the ceiling into vault-like portions; the suspension rods then terminate in drops or knobs, the ceiling may be composed of groined vaults with ribs and cross arches, on which is placed the covering of boards, and the apexes are ornamented by carved wooden bosses at which the ribs intersect each other. In Belgium and Holland, very graceful wooden ceilings of this kind were erected until the Renaissance period, for example in Harlem (Fig. 145) the coverings were made of boards bent by steaming, and the richest late Gothic vaulted constructions were imitated, but treated in a manner perfectly corresponding to wooden construction.

This structural principle transferred to horizontal roof trusses leads to tunnel vaulted ceilings (Fig. 146), which were very frequently employed in Dutch buildings, and were either covered with boards, or as may be natural to a people engaged in shipbuilding, were treated like ship-framed ceilings in the form of groined vaults, and if all the timbers are suitably m moulded posts, braces, and free-ending posts are properly carved, these ceilings are very pleasing. The horizontal beams that support the entire constructiou were decorated by painting, and in churches were generally utilized to form a passage, so that one could walk the entire length of the church along the lower part of the ceiling.

We have strayed into the domain of visible trusses and will now return to our starting point.

Beam ceilings should also be mentioned here, where the interspaces are not covered by boards but by tiles. I is easily s seen that this mode of constructing ceilings, hitherto only employed for stables, is capable of esthetic development, and m may also be used for other purposes; the same is true of ceilings composed of wooden beams set diagonally, between which are turned brick arches. Instead of tiles might be employed p slabs of stone, cement, slate, glass, etc., according to the purpose for which the ceiling is constructed. Board ceilings are wooden beam ceilings covered by boards on the underside. The expedients for their decoration consist of painting and in covering their joints by moulded battens, a division into a few large panels, each of which is enclosed by partly perforated and partly carved boards, as in a very pleasing church ceiling at Zug in Switzerland.

β. Paneled Ceilings.

Many of the wooden beam ceilings just described might also be termed paneled ceilings; but true paneled ceilings introduced by the Renaissance commenced as imitations of the classic coffered ceilings, but developed into forms quite different from those of beam ceilings. They are composed of intersecting beams, either having all the beams of large ceilings halved togetheh at the intersections, which are also strengthened by bolts or keys, some of the beams extending from one side to the other, the remaining beams abutting against these or being tenoned into them.

Since wooden beams of great length may be obtained, the web system may be employed as a basis for coffered ceilings. In his Five Books of Architecture, Serlio gives a beautiful coffered ceiling produced by the intersection of lines making 60° with each other.

Larger coffered ceilings appear somewhat monotonous, the Renaissance masters sought to avoid this monotony by replacing a group of coffers by a larger panel; these panels might be square, oblong or cross-shaped.

New motives for ceilings are produced by dividing the large panels into smaller ones by means of smaller beams, further by changing square into octagonal panels, by cutting off right angled triangles and thereby strengthening the corners, or into

cross-shaped panels by small beams placed at right angles, lastly by producing the ends of the smaller beams beyond the intersections with the larger beams. Compare the motives shown in Fig. 147.

A further improvement in this mode of constructing ceilings can be obtained by means of small beams set dingonally (Fig. 148), by tenoning the ends of small beams into the frames of separate panels b, and by the introduction of circular frames or of those cut to other curvatures. Further, these ceilings may be decorated by using beams that do not intersect but are merely tenoned together (Fig. 149). With these expedients we can obtain an inexhaustible variety of possible arrangements of ceilings, all derived from the simple coffered ceiling.

Many of the constructions are not to be considered as being very strong; it it is desirable to employ such, their pleasing appearance making them desirable in spite of their lack of strength, a series of beams is laid above the ceiling, to which it is fastened by bolts. This series of beams should be regarded as a web system, whose intersections can be arranged in various ways. At these points the paneled ceiling is to be bolted to the beams, and they may be decorated in the most diverse w ways by knobs, rosettes, etc.,. The motives for these paneled ceilings with an upper layer of beams to which they are fastened, are finished by web, embroidery, mosaic, lattice, chain and net systems. All division of surfaces exclusively consisting of curved forms may thus be used for paneled ceilings. As in beam ceilings, we man use large and small beams in paneled ceilings also.

The motives employed in the decoration of paneled ceilings are essentially similar to those used in paneling, stone and wooden beam ceilings. If what was said in the Chapter on that topic is recalled, we can easily establish fixed principles for the decoration of paneled ceilings, but it must not be forgotten that like all other forms of wooden ceilings, these must possess a peculiar character corresponding to the material, and that ornamentation by wood carving, gilding and color are especially appropriate.

It is self evident that lighter horizontal lattices may be bolte to beam ceilings, whose interspaces may be filled with

boards, producing boarded or battened ceilings subject to the same rules as lattices. Several very beautiful ceilings of the Italian Renaissance churches have turned this motive to good account. (See Celings from Verona in Semper's Der Styl).

3. Iron Ceilings.

Iron ceilings are partly used on account of safety from fire, partly because by the aid of this material the widest rooms may be covered with maximum elonomy of material and expense.

Besides iron, only stone and brick are employed for fireproof ceilings, wood being also used in those not fireproof. In general iron ceilings ase constructed of iron beams or girders, supported by heavy trusses for wider spans. What is to be said of the construction of girders will be given in treating of b beams and of iron sonstruction an connection with other things. It well here only be said in a general way, that cast and wrought iron girders require simple forms, and that the lattice assumes special forms with tne least propriety; further that forms of uniform strength are approximately employed for iron construction; finally, that painting with oil colors is required to protect the iron from rust, and that with this help the pleasing effect of iron construction may be materially enhanced.

Iron ceilings are preferably used for buildings intended only for ordinary purposes, therefore a minimum of artistic treatment is usually sufficient, if the entire arrangement is a pleasing one; the pleasing effect increases with the simplicity and clearness of the construction. Further in iron construction, the amgnitudes seen by the eye are small in proportion to the wide rooms that are covered; the external appearance of iron construction depends less on the forms of the individual structural elements, than on the mode of connection and their arrangement.

In iron ceilings not too far removed from the eyes of the observer, the iron beams should be ornamented by elegant mouldings or by perforated ornaments made of cast iron; but wrought iron beams made of rolled plates riveted together can have scarcely any form other than that absolutely required for their purpose.

If the interspaces between the beams are vaulted, the same rules apply that are given in the Chapter on vaults; if filled

by slabs of stone or wooden boards, their panels are to be treated like those of stone or wooden ceilings. If glass be used for this purpose it can be decorated by etching or engraving, or true glass staining may be employed.

4. Visible trussed Roofs of Iron and Wood.

Visible trussed roofs are ceilings supported by a combined and mutually strained system of connected members. These consist in general of horizontal ties and tierods, lastly of horizontal tiebeams connecting the end joints. If the supporting members are placed above the ceiling, this becomes a suspended beam, coffered or paneled ceiling, and the principles stated in the Chapter on those forms of ceilings are applicable. The roof covering of visible trussed wooden roofs is not supported by beams but by rafters, and these may directly support the roof, or purlins may be interposed between the roof and the principal rafters; the rafters are usually straight, but are rarely curved as in spires of the Barocco period. The supporting system of combinations of rafters is termed trusses.

α. Wooden trussed roofs.

For the covering of these roofs the form motives result from the ideas already given for the treatment of ceilings. The covering material of stone, tiles, glass, slates, wood, straw, m metal, etc., is usually fastened to a series of wooden battens, which may generally be decorated like other strips or bands according to their nature and purpose, if the covering material remains visible beneath, like all panels in interspaces. The supporting rafters, whether straight or curved, on account of their small resistance to bending should have greater depth than width like all other beams, and should be treated like beams. When opportunity offers, the principles determined for limiting forms determine the forms of tierods, struts and other connected parts. (See Tectonics, p. 195 et seq.). If the rafters or the main beams supporting the purlins are composed of curved pieces, they may be decorated by carvings according to circumstances, like those considered in various parts of our Tectonics and Architectonics.

As purely decorative expedients in visible trussed roofs, we man employ for filling interspaces between the structural members, perforated or solid panels of all kinds, also carving, painting and gilding on suitable prominent parts of the struc-

structure, metallic ornaments, etc.

A simple and clear construction is always the most important thing in all visible trussed roofs, whether of wood or of iron; abrupt transitions in the direction of different intersecting structural parts may be softened by transition curves in rare cases, almost entirely limited to massive roof and bridge constructions of rolled plates; it more than necessary to avoid such interventions, opposed to the rigid system of massive structures when construction and energy of effect for esthetic reasons neither require nor allow any softening or weakening by paltry trifles. Only in case of rafters of many truuses of wide span intersecting at oblique angles, is it often proper to insert large transition curves, which lend a bold sweep to such roof constructions; when such structures are used as in many roofs of railway stations, or in wide aisles of churches, halls, buildings for circuses, etc., are they entirely correct.

β. Visible trussed roofs of Iron.

The treatment of iron trussed roofs is similar in principle to that of those constructed of wood; according to what has already been stated, the difference in treatment of the separate parts results from the essential difference of the two kinds of materials, and the technical processes bependent on these. Economy of material and of weight, as well as the greater strength of iron members of equal section, compared with those of any other material, gives to iron construction a lighter character throughout than that of other constructions. The peculiarities of the modes of connecting the different parts, mostly joined by rivets, screws, bolts and keys, obstructs a free movement in the artistic form of iron trussed roofs, a freer play being almost entirely restricted to the parts composed of cast iron. Yet whatever is lost in richness of form by the rigidity and thinness of the iron construction, as well as by the difficulty of working the material, can be compensated in some degree by the aid of plates of cast iron perforated or decorated in relief, by decorations in thin metal, by ornamental details in wrought iron, which are considered in the Chapter of Tectonics on Locksmith"s Work, and lastly by painting in oil colors required as a protection from rust, and by gilding; further, since iron construction is never required to possess the

predominant monumental character of stone structures but always serves a purpose more or less temporary, a moderate use of zinc is not excluded, being an auxiliary material par excellence of our era.

5. Vaults.

The vaults preferably employed in architecture may be arranged in three classes, of which a brief description is advisable in the following pages for many reasons:- a, classic vaults; b, mediaeval vaults; c, Renaissance vaults.

Among classic or ancient vaults are to be mentioned tunnel vaults, domes, groined vaults without ribs and produced by the intersection of tunnel vaults. The name of mediaeval vault is applied to all construction of ribbed vaults derived from classic forms. We term Renaissance vaults all modern forms of vaults existing since the beginning of the Renaissance era, which were unknown to either the classic perior or the middle ages, welsh-groined vaults with or without intersections by tunnel vaults, the conical vaults of curved outline, only connected with ribbed vaults during the middle ages, etc.

We shall treat here neither of the historical development of the vault, not describe all the structural peculiarities of vaulted construction, which would be necessary in a treatise on mediaeval architecture or building construction, in order to understand the matter, and therefore touch but slightly on the historical as heretofore, and on the structural only as far as may be necessary for the derivation of the ornamental treatment of the vault.

a. Antique Vaults.

Roman vaults are well known to have been either built of stone voussoirs or of hollow pots stuck in each other, or lastly of separate principal arches connected by intermediate arches, the intermediate spaces between these two kinds of arches being filled by concrete. In most cases the surfaces of the v vaults were coated by plastering, since the excellent bricks and cement made uncoated stone vaults entirely unnecessary, or limited them to the smaller structures.

1. Tunnel Vaults.

If a series of arches are placed side by side the simplest form of the tunnel vault is produced; if the voussoirs are of

stone, the motive of hollowing ou their inner surface results from the requirement that the stones must be as light as possibłe, to lessen the horizontal thrust of the vault. This hollowing best corresponds in every relation to the formation of a rosette strongly raised from the sunken ground, and thus a sort of coffered ceiling is produced by the vault in the simplest way, entirely independent from the horizontal stone ceiling.

The idea of the tunnel vault with coffers being once accepted, a slight consideration leads to a further advance, the end joints of the voussoirs appear too prominently on the inner surface of the vault; they are concealed by decorating them by s sunken mouldings or by pearl beads. But the vault may be more tastefully constructed of supporting arches, each being stable of itself, preventing the arches from yielding sidewise by longitudinal connections, moulded like the arches or otherwise, then filling the interspaces between the two systems of arches by separate stone slabs, fitted in place. Thus are produced coffered vaults, similar in external appearance and allied in principle to coffered ceilings, because the supporting parts form a complete system by themselves, and only thin slabs of stone are required for filling the interspaces. Perhaps the most beautiful coffered vault constructed according to this principle, though in a somewhat developed form, is that of the sacristy of S. Spirito in Florence, a noble specimen of early Renaissance. A second very pleasing example is represented by Viollet-le-Duc, p. 125 of Dictionnaire Raisonnee d'Architecture. The intersections of the transverse arches and the longitudinal members are distinguished by decorated keystones.

If the voussoirs are small and of soft material like volcanic tufa, or are artificially prepared like bricks, they may be shaped in accordance with web embroidery or mosaic systems, which indeed has only been done in exceptional occasions, and preferably for decorative purposes. For example, Strack employed vaults of this kind in the graceful vestibules of Börsig's Machine Shops in Berlin. For plastic clay, the under surface of such ornamental voussoirs may be ornamented by pressing in moulds; soft materials like tufa may have carved, sunken or raised forms.

Semicircular and pointed tunnel vaults, when built of brick,

if half brick thick are entirely composed of stretchers parallel to the axis of the vault, while Dutch bond is used for thimker vaults.

Such vaults are most simply decorated by borders and by making their upper portion most prominent by means of colored bricks, also by the use of decorative patterns of bonds, which may be employed in tunnel vaults of low rise, are most tasteful if vaulted parallel to their diagonals like Fig. 150 a, b. The middle of the vault is then marked by the intersections of the bricks, and a decoration of the construction by means of colored bricks is appropriate to the middle and edges of the vault.

If long rooms are covered by tunnel vaults, these tunnel vaults are divided into bays by transverse projecting arches, partly to break the monotony of the vault and to obtain a greater variety in unity, and partly to make the vault lighter. The forms of these transverse arches will be considered, when we treat of mediaeval vaults in connection with other things.

A mode of constructing tunnel vaults by a series of strong brick arches connected together by longitudinal arches, the interspaces being then filled with concrete, a method of constructing vaults known to have been frequently employed by the Romans, fully explained by Viollet-le-Duc leads again to the coffered vault.(Dict. Rais. IX, p. 485 et seq).

β. Roman groined vaults.

Groined vaults of the Roman system produced by the intersection of two tunnel vaults, the diagonal arches not projecting beyond their surfaces as groin ribs, are to be treated like tunnel vaults. If the vaults are of stone, since the curves of intersection of semicircular equal tunnel vaults are elleptical, the separate stones of the diagonals must have peculiar forms, and each stone must be determined separately, so that the tunnel vaults may unite in a good bond. Since the tunnel vaults rest on these diagonal arches by means of the indentations of the bond and heavily load them, they must either have a depth greater than that of the vault, or be constructed of a stronger material than that of the vault, so as not to be crushed under the load. This strengthening of the diagonal arches then expresses the greater importance of these over the surfaces of

the walls themselves, either by a material of a different color, by a special mode of decoration, or by a greater prominence of the lines of intersection of the vaults in the form of ribs, wrought on the stones of the diagonal arches to strengthen them.

The inconvenience of determining and working these diagonal stones with their complicated joints naturally leads to the i idea of strengthening the diagonals by constructing the diagonal ribs as if standing independently, then letting the surfaces of the vaults intersect above the back of the ribs.

The plan of a Roman tunnel vault with longitudinal and transverse arches but without special projecting ribs was formed as at Fig. 151 a; that of a vault with diagonal ribs as at Fig. 152, b, in case that care had previously been taken to provide a complete support for all the arches of the vault by arranging supporting piers in the plan. But in case not only the latter were required, but the cutting of the springing joints of the arches was to be simplified, as well as to obtain a perfectly free development of all the separate arches of the vault, the piers c (Fig. 152) required the addition of a projecting member in the direction of the diagonals.

Thus the ribbed vault was developed from the construction of the Roman groined vault in accordance with the requirements of expediency; if the ribs are to be entirely omitted and the vault is so well built or its loading is relatively so small, that they can be omitted, then a (Fig. 151) becomes the plan for the normal arrangement of groin vaults. The Renaissance is known to have entirely followed Roman architectureand gave absolute preference to the groin vault without ribs, over the mediaeval vault with ribs.

γ. The Roman dome.

The dome is bounded by spherical surfaces; all sections through a vertical axis and passing through the vertex are great circles. From structural and decorative reasons, we are obliged to distinguish between domes simply taken, or hemispheres, half domes or quarter spheres, and lastly domes constructed on polygonal, square or triangular plans, the so-called pendentive domes

The simplest mode of constructing domes is to compose them of horizontal rings of voussoirs, all their beds and end joints being directed toward the centre of the dome; each voussoir t

therefore has two radial beds and two vertical end joints. The apex is cormed by a conical keystone, its under surface being concave spherical. If such a dome is built of cut stone it can be made a coffer dome by applying the principles already found to govern tunnel vaults of stone. If it be built of brick, for which purpose block bond entirely composed of headers is usually chosen for both structural and economical reasons, but ornamental bonds are not to be exmluded from small domes, the decorative motives that may be produced by these bonds give abundant means for the ornamental treatment of the surface of the dome; the general ground principles are conclusive in this case, as in all Tectonics, the border form at the base of the dome, its detached apex, the courses in horizontal rings, the vertical and diagonal directions of the brick bond, all furnish starting points for the entire decoration.

The dome may also be regarded as being divided into sections by meridians, which diminish toward the vertex, and may be composed of blocks of stone having thinned edges toward the apex; this unpractical mode of construction should be regarded as merely fanciful, but was a great favnrite in the late Renaissance of Holland, for niches and small domes.

A combination of the two modes of construction is found in the use of coffer domes, in the architecture of the Romans and the Renaissance, carried out on the greatest scale in the Pantheon in Rome. A series of vertical arches diminish toward the vertex by offsets and form great circles of the dome, and are connected together by transverse arches, the interspaces between the arches are filled by coffers. (Viollet-le-Duc. Dict. Rais. IX. p. 475 et seq.).

In the dome of the Pantheon a refinement was first employed, which had a pernicious effect in later times, and led the Renaissance masters into error; the side surfaces of the hollowed coffers without exception radiated from a central point in the axis of the dome, so that instead of the coffers was introduced a perspective architecture, which only appeared in some degree correct frog the centre lying in the axis of the dome, but had a distorted effect from any other point of sight; at this centre the side surfaces of the coffers entirely vanished from t the view of the observer. For our modern era to commend this

theatrical effect as an ingenious idea as frequently happens, can scarcely be termed otherwise than an error of judgement of the esthetic faculty. The lower edges of the coffersonly should be inclined downward, so as to all becnme visible,but not the others.

A peculiar form of dome is obtained by constructing it of h horizontal rings and also with sections diminishing toward the vertex, if the vault is executed in herringbone bond as in the dome of Florence cathedral. This produces a pleasing arrangement that may be decorated in various ways by the use of colored bricks. According to an allied principle a dome may be conceived as being formed of separate spherical triangles or rhombuses, their sides forming great circles andpartly spherical spirals on the surface of the dome, which terminate at the vertex, a mode of construction never yet executed, though allied to many late Gothic star vaults.

On the plan of any dome may be drawn a regular system of straight lines, that are to be regarded as being the horizontal projection of a system of circular arcs lying on the surface of the dome. The separate spaces of such a regularly divided domical surface may be filled with brick masonry, regularly arranged in a fixed direction. We find two separately existing and very strong domes in the temple of Jupiter at Spalati, and in the temple of Minerva Medica at Rome; the former consists of horizontal series of arches turned over each other, the interspaces being filled with concrete, the other being of doubly curved vaults turned between meridian arches, so that the dome is shaped like a muskmelon. Strictly speaking, the mediaeval ribbed vaults of all kinds are nothing but combinations of regular systems of ribs, whose intervals are filled by similar vaults of double curvature, which are partly spherical-elliptical, partly horn-shaped ellipsoidal surfaces like those of the melon vault. (Fig. 153).

The domes built of pots employed not only by the Romans but also by many modern architects for covering wide rooms with the minimum weight, hardly require consideration, since they are almost always covered by plastering. If the construction of such domes is to remain visible, the bottoms of the pots would be placed toward the centre of the dome, the joints be filled with mortar, cement or plaster, which might be painted

or gilded, while the bottoms of the pots could be ornamented by pressed ornaments.

The half domes of niches are chiefly distinguished from domes in their construction and decorative treatment by the fact, t that generally not their vertex but that point on their lower edge farthest from the eye of the observer is to be regarded as their pole, so that the axis of the half dome is horizontal. If the half dome is to abut against an entire dome so as to resist the thrust, as in many buildings having the plan of the Greek cross, or terminates in a tunnel vault, it should be constructed as a half dome with vertical axis and be decoratively treated accordingly or like an umbrella, while domes over niches from the earliest times are usually treated in forms like a muscle shell and thus termed a concha. The concave attracting and inviting character of the niche leads the eye to the pole of the half dome or concha, and appears at that point of the construction where the eye feels restricted, from whence the energy of the whole appears to radiate, and which seems to have retired to the farthest point. Similar ideas had led almost all nations to decorate the concha by radiating forms, as if pencils of light radiated from the pole in all directions, which may be compared with those of the sky when the sun sinks below the horizon. Hence in churches the pole of the niche is usually ornamented by the face of the divine being represented, or by a symbol representing this. Roman and Renaissance architects generally preferred to decorate the conchas of small niches by shells, especially in case of fountains and cascades.

In Holland during the late Renaissance it was a favorite idea to construct the domes of niches with radiating voussoirs diminishing toward the pole, this was carried so far as to cut bricks to form sharp intersections at the pole, while the radiating lines of the brick bond were only a quarter brick apart at the outer edge of the niche.

All entire domes and domes over niches may then be termed u umbrella domes if their vertical axes are accented, whether actually divided in sections by great circles, or meridians and zones are only indicated as in church domes, sprinkled with stars or decorated by soaring angels, etc.; all those domes over niches may briefly be termed shell domes, in which the pole of the principal axis is treated as the principal point;

to decorate an entire dome by taking any axis other than a vertical one as a base would be nonsense, and the same would be true of a niche dome in which the top and rear were ignored, while the right and left sides were made prominent. (See Tectonics, Chapter on order and estimation, p. 81 et seq.).

Pendentive domes are produced by constructing a polygon of any form whatever, whose angles lie in a circle or in an ellipse, if the dome is to be elliptical. In architecture this is usually merely a regular polygon with three, four, five or six sides. All regular pendentive domes are in part directly supported by the piers; for example by the piers a, b, c, d, the remainder resting on the arches a c, c b, b d, d a, erected above the sides of the polygon. The radius of the dome equals the radius of the polygon circumscribed about the polygon, and therefore equals the half of the greater diagonal of all polygons with an even number of sides. If a plane be passed through the vertices of the arches, which have equal heights, for regular polygons, this separates the pendentive dome into an upper calotte and as many pendentives as the polygon has angles. The p plan of the calotte is identical with the circle inscribed in the polygon.

The pendentive dome should always be decorated from a different point of view than the dome; besides the vertex it has n lowest and n characteristic points, corresponding to the centres of the arches, which require esthetic prominence, they are usually constructed by making the courese horizontal and corbelled out diagonally in the pendentives up to the base of the calotte, which is then constructed alone as a dome. Hence the decoration naturally has reference to the characteristic points, or if the calotte be constructed independently from the pendentives, which is perfectly proper when those are built of horizontal courses, the characteristic points are not made prominent on the calotte or are merely indicated. The borders and t the prominence of the vertex by a keystone will be decisive in both cases, and the indication of diagonal lines in the first case, and the development of the pendentives in the second, will be equally so. The pendentives gradually increase in width upward from the piers, and afford opportunities for the introduction of polygonal or circular medallions; they may be so d

decorated, that the ornament is gradually developed from the lowest part of the calotte. The calotte should be divided from the pendentives by a border or a cornice.

All domes, whether segmental, semicircular, elliptical or of other forms, require a keystone to terminate the vault.

The smaller the rise of a vault the less is the load that it may safely support by its conditions of stability, and the greater its rise as in case of a pointed arch, an elliptical arch with vertical major axis, a parabolic or catenary arch, the g greater will be the load which may be placed on it, and also the greater will be the weight that is required to be placed on its vertex to ensure its stability.

Further the completion of adome is always technically difficult in vaults of great span, and an opening is commonly required at the vertex, partly for the admission of light, partly for the purpose of hoisting building materials, etc. From these points of view, the following rules for special cases are derived; Segmental and semicircular domes of small span are not properly finished with a keystone, which in very small domes should be so shaped as to exert no thrust. If the diameter of the dome exceeds a certain measure, a complete stone ring is preferable to a keystone, the centre remaining open for admitting light, hoisting building materials, and which can at last be filled with a stone more or less flat.

Stilted or raised domes with a height exceeding their radius must be loaded in a peculiar way and therefore require massive keystones, which may be bold suspeyded rosettes in complete d domes, or should be a circle of heavy, thick and deep voussoirs in domes open at the top. In very large domes like those c covering the Pantheon at Rome, the cathedral of Florence, the church of S. Peter at Rome, the church od S. Ginèvieve in Paris or of S. Paul in london, three domes are palec above each other, the lowest or true dome having an opening at its centre, the second being steeper and supporting the lantern, while the third is the external covering dome, whose weight with that of the second dome combines with the horizontal thrust of the first dome as a vertical pressure. The upper ring of the inner dome may then support a gallery and may be connected by a colonnade with the upper cosing ring od the second dome, which

supports the lantern; but this colonnade should not cause too great a load on the lower dome, nor should it support the closing ring of the second dome, since in both cases the lower dome would be in danger of falling, and the second dome would be useless.

The closing rings and keystones of domes being the highest and most prominent structural parts give opportunity for particularly rich treatment, in lightly constructed domes of low rise, the requirement that the crown of the dome should be loaded as lightly as possible demands the use of hollowed sections in the closing ring, which then more or less closely approximates the form of the edges of a flat dish, while on the contrary, strong domes that require loading need to have their deep crowns loaded with as much weight of decorations as possible.

Pendentive domes permit the construction of hemispherical or stilted domes in place of a calotte above the cornice, which terminates the pendentives, a mode of construction especially peculiar to Byzantine architectura, which was retained in the French Romanesque style and which is justifiable in many cases.

In connection with the treatment of towers, we shall describe domes in connection with their supporting walls and arches, f forming transitions from the square to the octagon, which are found in mediaeval towers over intersections, as well as in other towers and domes of churches.

b. Mediaeval Vaults.

Mediaeval vaults are ribbed and are based on the groin and tunnel vaults and the dome, but their separate surfaces are constructed as portions of domes between the ribs. In addition to these are cloister vaults that require mention.

α. Mediaeval groin vault.

We have followed the structural principle of the Roman groin vault so far as it was developed without becoming untrue to i its character, which is always based on the intersection of two tunnel vaults. The elliptical form of the diagonal ribs caused inconveniences in stonecutting differing for each separate st stone. The mediaeval groin vault sought to free itself from all inconveniences of the Roman groin vault, and formed the diagonal ribs as semicircles. Then this arrangement is only a attained with consequences more or less troublesome; if the

side aisles are semicircular, their crowns are lower than those of the diagonal ribs by the difference of the half diagonal and half side; the vault must then rise from the side arches to the crown, unless one is willing to raise the crowns of these arches to the same height as that of the vault, either by making the abutments of two different heights, which produces a very awkward treatment of the capitals, or by stilting the side arches, which is not very pleasing.

The inconveniences are increased when sectangular bays are to be covered by groin vaults, and both side and groin arches are to be semicircular; we must then have different heights of the crowns or of the abutments, or stilt both kinds of side arches. In lectures on mediaeval architecture every expedient for the removal of these inconveniences is described, that was employed by the Transition and Gothic styles. We shall here only treat these from the material stand point so far as the decorative development may be concerned.

The use of the elliptical arch for diagonal ribs may be avoided if an oval arch be substituted for it, and if this be struck from as many centres as possible, it is hardly inferior in its continuity; if the diagonal arches are semicircular, the side arches require to be stilted by agout 1/8 their radius, since the abacus of the impost moulding of the pier would otherwise conceal the lower ends of the arches, which looks worse in arches of small span than in those of wide span with an equal projection of the abacus; but for the vault to rise from the crowns of the side arches to its own crown is not only not ugly but is even preferable on esthetic grounds, if the lesser illumination of the crown be neglected. Such vaults do not convey the idea of pressure but that of a free sweep, and an increase in the height of their crowns corresponds to an increase of span. In low rooms retaining the same heights of crown and side arches, we can employ the expedient of placing the springing joints of the diagonal arches below those of the side arches, or the segmental arch may be used.

As for the introduction of springing points at these different heights and the correspondingly varied capitals, this arrangement is incontestably the richest and most pleasing of all possible methods on account of its variety, the most pleasing

and consistent structurally but also the most costly; to be willing to sacrifice for this reason in monumental structures because the end may be attained by simpler means, as unfortunately done in the more perfect Gothic, is to be robbed of one of the finest art expedients by poverty of ideas. If it is desired to employ in exceptional cases the extreme means allowable in art, when everything normal seems trivial, one should then not fear the higher cost.

In case of poverty of construction or mean proportions of the room to be vaulted, a moderate stilting of the arches as well as a moderate raising of the crown of the vault forms the means best adapted to produce the extreme measure of a pleasing effect, attainable by greater propriety. In quite oblong groin vaults the heights of the crowns of the arches on the longer sides and those of the diagonal arches approximate each other in some degree, but on the contrary the end side arches require to be considerably stilted.

It is well known that the early Gothic style employed suitable expedients and made the side arches pointed to obtain control of the heights of their crowns without being compelled to use the circular arch, which was only retained for the diagonal arches. They then had the choice of constructing all the side arches with the same radius as for the diagonal arches, and which is technically preferable because all voussoirs can then be wrought by the same template, special imposts and keystones only being required; the crowns of the three arches are then not at the same height; or the heights of the arches are arranged at pleasure, making the pointed arches dependent on these, which may then be made equilateral pointed arches requiring to be stilted, or so that the narrow or side arches are lancet arches with a common springing plane.

It is always most judicious to use a single radius for all the arches, to allow the crown to rise gradually, and to stilt the arches about 1/8 their height. To make the groin arches pointed is entirely useless, in case the vault be not very heavily loaded.

The pointed arch is to be preferred over the circular arch for the side arches, because with a moderate difference from the round arch it is more piquant, aspiring and dignified. If

we once become accustomed not to recognize the Gothic style in every case in which the pointed arch may be used, it becomes allowable in the Renaissance as well, to be employed whenever appropriate. The early Renaissance disdained it as little as Gothic rejected the circular arch; the spirit of each style was too discreet to reject anything practically usable, from blind subjection to principles.

The separate compartments between the ribs were always so covered in mediaeval vaults as to make their highest line curved, and they therefore became parts of domes. Two modes of vaulting were in use, the vaults being either constructed after the classic method of building tunnel vaults by courses at right angles to the axis of the tunnel vault, or diagonally in later times so that the length of one half the side arch being transferred to the diagonal arch gave the point, which was connected with the crown of the side arch. The other points of t the diagonal arch were connected with the corresponding points of the central curved line of that compartment of the vault. The separate portions of the vault very heavily loaded the diagonal arches in the first case, but in the second they intersected above the ribs, so that this bonding together was of i itself quite strong, and the ribs proper had but little to support and served rather as stone centerings to somewhat relieve the vaulting.

If the vault exceeds the normal width of the smaller bays, as first happened in the vaults over the intersections under the towers of the larger French cathedrals, there were two modes of dividing the groin vault into smaller compartments, it was either divided in plan into 8 equal though smaller compartments to form octopartite groin vaults; the inconveniences of springing points of unequal heights, of unequal heights of crowns, of stilting or the use of different forms of arches were increased, for a d and d b (Fig. 154) become semicircles, and a c and d c are different quadrants if pointed arches are avoided; but if they are used the diagonal ribs a c, b c are quadrants, c d and c e are half pointed arches, while a d, b d are either semicircular or are entire pointed arches, the problem may also be solved by the use of segmental arches without introducing too many unpractical results. Or the

groin vault may be divided into smaller compartments by cutting each of the original compartments into three. The results are as follows; a d + d c (Fig. 155) is greater in plan than a c; if the crown of the vault is to be its highest point, which is not absolutely necessary since a vault may rise higher than i its crown, when the crowns of the side arches are higher than that of the vault, causing the centre lines of the compartmenbs to descend toward the keystone, the radius of the longes arch, as a d + d c is to be taken as the basis of the construction of the vault; in the later middle ages this arch was termed the "principal arch." The keystone c is at the height of a d + d c. The point d' lying above d has the height d d' in the vertical projection. How shall the crown c of the vault be connected with the springing point a? If the half diagonal a c of the plan be laid off in the vertical projection from a to c'., a brief consideration proves that the vault rib above a c of the plan must be a pointed arch differing very little from the semicircle a d + d c.

On the contrary, if the diagonal be assumed as a basis for the construction and the diagonal rib be made semicircular, the crown c of the vault is lower than in the first case, its height being a c. If a d (Fig. 156) be drawn in the vertical projection, and d c of the plan be laid off from d to c", the point above c" does not have a height equal to that of the crown c' of the vault but is lower. Therefore in general this method leads to no result. One must rather either strike an arch from the point d" over d to the keystone c with the radius of the diagonal rib (Fig. 156), or transfer the magnitude c d of the plan from c to d"' towards a, erecting a perpendicular d" to cut the quadrant in d'". The height d'" is then that of the point lying over the point d of the plan. We may now strike an arch from d'" toward a with the radius of the diagonal rib, or draw a segmental arch with the same radius whose centre z lies on the line d'"d" produced, cutting off the height a d"" over the springing point, or lastly a circle may be drawn through d'" with radius a d tangent to a vertical drawn at a. It becomes evident that turn and twist as we may, inconveniences will result always and must be taken into account.

A few considerations connected with observations of actual

structures will place the various difficulties in a correct light, which result from the construction of groin vaults in accordance with mediaeval principles. If the sections of all vault ribs and side arches are similar, or those of the side arches are composed of the sections of one rib and two half ribs, it will always be preferable to employ a single radius for all ribs and side arches, to simplify the process of construction. In this case one has only a choice of using segmental or pointed arches in addition to the semicircular arch of the diagonal rib. The form of the segmental arch is generally associated with the idea of the secular, of the absolutely essential at the expense of beauty and of the mean, while with the pointed arch is joined the idea of the ecclesiastical, the monkish, which is not agreeable to every one. This contains a hint concerning the choice of one or the other form of arch. If the segmental arches are neither principal ribs nor side arches but only intermediate ribs, they are not unpleasing in contrast to circular or pointed arches; since their oblique springing from the vertical gives a picturesque effect to the vault; vertical division walls rise from a to d"" and d'" in the example (Fig. 156), if the arch d""dIV be segmental, whose joints remain horizontal up to the commencement of the compartments of the vault and are limited by the rib d""d'".

To take a fancy to the exclusive use of circular arches would in many cases result in the greatest amount of labor with an esthetic effect affording very little pleasure; highly stilted arches appear well only in exceptional cases, and a strong curvature that detaches small circular arches from their tangents is very disadvantageous. To discover the best relation between the amount of labor and a pleasing result in a special problem frequently requires many trials befora a decision can be made.

The two examples of the division of the groin vault into several compartments include all complex varieties of multapartite and ornamental groin vaults. Multapartite groin vaults may be erected on any polygon, the heights of side arches may be assumed as required, as well as that of the vault, since the crowns of the arches may be arranged to bring the springing points of these arches high above those of the diagonal ribs, which is often necessary in vaults of towers, or desirable for

free admission of light and to avoid transmitting the horizontal thrust of the compartments of the vault to the side walls, the vault then rising considerably from its keystone to the s side arches.

The richest and most complex ornamental vaults are easily solved by the simple example, among which we include all ribbed vaults divided in compartments in various ways, which may be derived from the groin vault with the exception of the star vault, which is to be regarded as an ornamental vault; still structural investigations are to be made in each individual case to make it as clear as possible. Ef one starts from the principle that the crown of the vault must be its highest point, that all its ribs must have the same radius of curvature, and all intersections of the ribs must always be higher toward the crown, the 'principal arch' of the vault becomes greater than the half diagonal and = a b + b c + c d = the sum of the distances between the horizontal projections of these intersections, by means of which a constant increase in height is possible, between the springing point and the crown. To the points a, b, c, d, e, f of the plan correspond the heights a a, b b, c c, d d, e e , f f of the vertical projections. From c g of the plan we obtain c g on the vertical projection with the curve c'a', or b g" with the curve b'a'". The height e e' can then be always taken at pleasure. If the half diagonal a f be taken as the principal arch, lay off from f on the vertical projection (Fig. 158) the distances f c, f b, f e toward a, erecting perpendiculars at those points, whose intersections with the quadrant a f' with radius a f' give the heights b, c, e, g, f. all points then lie on the surface of a sphere, and the vault then becomes an ornamental vault, which we term a star vault.

If the largest possible principal arch = a g + g b + a b + b c + c d + d l be taken ar the basis of the construction, the rise of the vault would be great (Fig. 159); if a low ellipse or a Tudor arch were taken instead of a circle, a favorite form in the late Gothic of the Netherlands and of England, the heights a, g", b", a", d", f" would be obtained, or the points a, g'", b'", a'", c'", d'", f'".

If one does not follow the two previous modes of procedure, for determining the altitudes of the ornamental groin vault by a single radius, but first assumes the height of the crown a,

the side arches A B and B C (Fig. 160).connect these crowns by the arches a′d′, which correspond to the simple curvature of the groin vault, transfer to the vertical projection the lengths a b, a c, a d of the plan, erecting verticals at b and e, which intersect the curve a′d′ in b′c′, there will be obtained an ornamental groin vault, all whose ribs will be constructed with different radii. The two first modes of construction may be termed German, and that just described is French; it was chiefly employed in France and England during the middle ages. Vaults on the German plan generally have some advantages over the last, which produces a monotonous and consistent effect, while on the contrary the former appear rather capriciously v varied. On practical grounds they are to be preferred to the French.

β. Mediaeval domical vaults.

Simple mediaeval domes are constructed differently from the Roman; in general the dome was not much liked. The ornamental domical vaults of the late middle ages, which we have already considered as star vaults, are preferably employed for covering polygonal rooms; all intersections of the ribs lie in the surface of a sphere, whose radius equals that of the inscribed circle. The compartments are covered as spherical surfaces of small curvature between the ribs.

Since the compartments are the stronger in both groin and s spherical vaults, the more that they are curved in cross section, i.e., the greater the rise of any single arch of the compartment in proportion to its span, in strong vaults these compartments are sometimes so strongly curved, that their highest point is considerably above the crown of the vault (Fig. 161). Such so-called "full breasted" groin and spherical vaults appear more animated and varied than the "flat breasted", since the strongly curved compartments afford a richer contrast of light and shade. Therefore the "full breasted" are to be preferred, if not painted, to the "flat breasted" if painted.

γ. Mediaeval tunnel vaults.

The simple mediaeval tunnel vault without ribs differs as little from the Roman as the simple dome, but the ornamental tunnel vault is different in very essential points. That of semicircular cross section is formed in the simplest way by

making the half span a c (Fig. 162) equal to the height c c′; the altitude of the point b equals that of c′, since a b = a c′, consequently the points b, c, b are connected by a straight p piece on the vertical projection.

The construction is suitable for elliptical vaults required for low rooms. If the rooms are very low and require a height less than the half span, one may take as a principal arch a s segmental or Tudor arch as in the Netherlandish and English system. Yet the most natural mode of constructing the ornamental tunnel vault will be to take the diagonal arch a b c b a (Fig. 163 as the principal arch, which is made a semicircle; all ribs are then made with the same radius and all intersections lie on the surface of an elliptical tunnel vault, whose major axis is vertical. (Fig. 164).

In larger rooms a second series of ribs is inserted between those of the first system (Fig. 165), and which are constructed on the same principles. Further, ribs can be struck to the side walls as segmental arches with springing points lying above the general springing lines; the tunnel vault may be further ornamented in the most varied ways. All these constructions and t their variations being fully treated in any good manual of Gothic construction, we have here only to consider those matters most important in modern practice. These ornamental vaults of all kinds have intimate relations to the Roman coffered vaults, as may easily be seen, essentially differing from them only in having vaulted compartments instead of coffers. As we have seen, the ribs are unnecessary in the mode of vaulting at right angles to the axes of the compartments, strictly speaking, since the brick bond of the compartment forms a species of stiffening rib along the intersecting edges, that does not project b beyond the surface of the vault.

The late Gothic sometimes employed ornamental vaults without ribs, whose compartments have the form of sunken pyramids with curved surfaces, thus being vaulted ar cloister vaults with slightly curved inner surfaces (Fig. 166), especially in Saxony. Such vaults specifically belong to brick construction and deserve to be imitated in purely technical buildings, and when it is desired to produce a rich effect with small means.

6. Decorative motives of mediaeval ribbed vaults.

The definitive elements that settle the external appearance of the mediaeval vault are the ribs themselves before all else, their geometrical arrangement already considered, the proportions of their dimensions to those of the compartments, their profiles, keystones, developments above their imposts, and lastly the decoration of the compartments.

The treatment of the imposts will be considered in connection with the forms of the supports and of their capitals, and we shall therefore her limit ourselves to what is to be said of the vault itself. This has been sufficiently explained from esthetic and technical stand points. it only remains to state that the side arches, which in rooms containing free supports connect these together and wit the walls, make strong archivolts and smaller ribs necessary and desirable for both technical and esthetic reasons; if the side arches support heavy loads like those of churches supporting the walls of the clearstory, or those of warehouses, cellars, etc., that support goods, furniture, implements, men and other external loads, they must again be strengthened. Rooms containing several aisles and having a raised central aisle, require very strong longitudinal pier arches, arches of less strength to connect the supports and serve as transverse arches, but ribs to support the compartments of the vault, whose strength is only proportional to the weight of the vault. For such vaults to produce the impression of great strength, and so that the entire structure may have that of power and reserved force, the archivolts and ribs must appear massive in proportion to the compartments of the vaults; on the contrary for lighter constructions to have the effect of lightness and grace, the side arches are entirely unnecessary in lightly loaded vaults and should be replaced by ribs.

The ribs and side arches act like girders and similarly to loaded beams of curved form (Fig. 167); i.e., their strength increases more rapidly with the depth than the width on one hand, on the other the fibres most distant from the neutral axis are most strongly stressed. From this results for structural reasons the requirment in relation to their form of section, that its depth should exceed its width, that it should be strong at top and bottom, while it is allowable to reduce the section between those limits. In the older mode of vaulting,

when the separate courses are perpendicular to the axis op the compartment, the ribs and arches have a strengthening addition at their upper edges (Fig. 167), against which abut the compartments; but this addition is unnecessary in the diagonal mode of vaulting; therefore strong ribs and arches convey the impression of strength, and the permissibility of reducing the section between intrados and extrados allows the use of coved mouldings, while the intrados fulfils its function as a massive round. In case of unloaded or slightly loaded ribs, their sectional forms and proportional dimensions may be determined indepently from the conditions of loading. Hence the German Renaissance decorated with fillets the ribs of a ribbed vault, (Fig. 169), constructed according to Gothic principles, and this makes the light loading evident. These ribs have a very pleasing effect where used; the rows of leaves on both sides are decorated by pearl beads, cable mouldings, etc.

The sections of strong bearing ribs in which mediaeval architecture was very fertile are yet restricted within very narrow limits; the lower edge alone appears most powerful and bold, when treated as a round or pointed bowtell; at a distance the pointed bowtell has a more energetic effect than the round, w which may also be replaced by a cove or a sharper edge; all a attempts to replace these very simple forms by those more complex are without result, since it is so easy to fall into littleness. The middle ages created in the profiles of the ribs, not merely members peculiar to its architectural styles, but corresponding to the developed vaults and of enduring value; leaf mouldings with pearl beads and bands, which express the relations of the ribs to the vaults as bearing members, and harmonize well with the sections of the ribs. Therefore it is scarcely reasonable to refuse to use the form because originaliar to the classic styles. The mediaeval motive of using bands set with semi-precious stones to separate rounds and hollows is also very appropriate in the decoration of the ribs, and is effective at even a considerable distance, where other forms become indistinct.

Only in vaults intended to be close to the observer may the separate mouldings be enriched and be divided into smaller parts, yet even in this case a bold treatment of the section of

the rib will always be best.

The side arches that support the walls must have breadth as well as strength. In this lies an essential difference from the smaller ribs, and on it is based their different decorative treatment.

The breadth of the side arches is determined by the thickness of the walls that they support, and since the strength of the side arches also increases with their rise, the two requirements of breadth and strength will be sufficiently satisfied if they are built of several rings of courses, whose depths are determined by the thickness of the layers in the quarry. The side arches accordingly consist of two or three courses of arches according to the thickness of the wall and the loading, and these may be arranged in full or half steps as required, so that the side arch produces the impression that the walls, of their own motion and their strength have laid bare their interiors. The simplest and most appropriate mode of profiling the side arches consists in arranging these sections in s steps or "orders", whose alternation of light and shade gives the boldest effect. their relation to the burdening compartments of the vaults is made evident by the elastically curved rows of leaves with some fillets (Fig. 171). If the profile is to have a richer form, the angles may be replaced by separate groups of a round betweey hollows, giving the impression of energetic force, and if it be desired to strengthen the lower end of the stepped side arch in reality as well as in appearance, a pointed bowtell will fulfil this purpose in the best way. By rational procedure we thus reach forms similar to those introduced by the middle ages in its grandest churches; we can never dispense with these model profiles belonging to the 12 th and 13 th centuries in case of similar problems, but on the contrary all the albored refinements, which were such favorites in the late middle ages, should be thrown aside as being practically worthless, though historically interesting.

Since the side arches not only support the vaults, but also keep the piers apart and at the same time connect them, and are arranged in connection with each other, their horizontal lower surfaces may receive band-like patterns which express this connection. All periods and nations have expressed this idea, each in its own way.

Smaller vaulted rooms, whose piers are connected by side arches and which are coveeed by ribbed vaults, do not require massive side arches unless exposed to unusual loads; such side arches may very well be treated as broader ribs in case of small and lightly loaded vaults, since they principally act as abutments on the wall surfaces for the compartments of the vaults and will then be portions of a side arch, so that the other sections may be obtained from that of a rib by doubling or halving its width.(Fig. 172). It is then perfectly correct and is also one of the simplest and cheapest of decorative expedients to replace the angles of the ribs and side arches by chamfers or coves, to increase the effect of light and shadow.

In most cases if columns are connected by arches, Roman and Renaissance architects have treated these arches like the classic architrave corresponding to stone beam construction, even forming coffers in the under surfaces of these archivolts. The Roman and Renaissance masters have either committed a fault in treating the arches like curved beams of stone, or our ideas of the meaning of the form of the archivolt are incorrect, and they must be correct.

The architrave form as a supporting stone beam above a colonnade was peculiar to Grecian architecture, its division into several horizontal courses, the decoration of its under surface by band-like patterns, expressed the idea that the columns should be connected by a tightly stretched band, on which a load might be laid without causing it to bend.

But the Greeks themselves employed this architrave form to enclose windows and doors, and even used it as an archivolt at the aqueduct in Athens, and it therefore becomes untrue, or othe associations of ideas have become connected with these forms; in this case the Roman and Renaissance masters simply accepted the forms of the Greeks, perhaps without understanding the ideas associated with these forms by that people. But they seem to have differed from those which we have been accustomed to connect with the architrave.

The classic styles conceived an opening in a wall as merely a hole, separated from the masonry of the wall by a bordering frame, but the middle ages regarded it is an opening producing the appearance by its simple splays or recessed steps, as if

the wall had opened of its own accord, laying bare its interior. it is self evident that bordering frames are not wanting in e even mediaeval walls, but are arranged beneath the supporting side arches which play the chief part, the structural elements predominating even if the construction is not of the greatest importance, as in wheel windows and in other principally decorative works. The Greco-Roman architrave is not only the band connecting the columns, but is more generally the dividing member, which separates the open interspaces between the columns from the frieze and cornice, the masonry of the wall from the roof cornice, and the opening in the wall from the masonry; it acts in different ways and for different purposes, and its meaning will therefore depend on the system of construction employed. To divide its under surface into coffers would be opposed to its significance; only the tunnel vault requires to be lightened by coffers, but neither the architrave nor the archivolt; its under surface is adapted to free ornament, which c connects it to the points of support, but the coffers are only appropriate for actual tunnel vaults. The archivolt constructed on the Greco-Roman principle unites very well with the mediaeval vault, so long as the development of the pier is in accordance with the classic principle, i.e., if the pier affords separate abutments for the imposts of the arches, so that each arch may be freely developed. On the contrary if the imposts are so formed that the ribs and side arches intersect and interpenetrate at their ends, the archivolt cannot be developed throughout its entire extent, the piers become true clustered piers as in the best mediaeval period, and the archivolt has then lost its significance, and it is preferable to treat the ribs and side arches in accordance with mediaeval principles.

The treatment of the pier, capital, and impost stones, will afford us an opportunity to return to these points, and we still have to treat of the massive arches employed in bridges, viaducts and similar technical designs; still we shall speak of these constructions in considering the connection of piers and columns by entablatures and arches on one hand, on the other the same is true for these as in case of tunnel vaults, and partly the results of our investigation s on openings in walls. We must here refer to those Chapters.

Ribbed vaults as well as domes and Roman groin vaults require keystones for structural reasons, and for which what was p previously said is true; if the vaults are light, they need n not be unnecessarily burdened by the keystones, but if the require great strength, the diagonal ribs must be constructed as projecting arches, as a pointed arch may be erected that requires a special load at its apex. The keystone supported by the ribs is most appropriately and characteristically decorated by a suspended flower, a garland of leaves and flowers, by allegorical representations, shields, heads, etc., and its width may correspond to the greatest breadth of the arches at the point where the ribs abut agains it (Fig. 173).

If the keystones serve to suspend chandeliers, or if bell or scaffold ropes pass through them, they must be perforated, and their decorations must be arranged around the central opening; if bells, building materials, etc., are to be hoisted through them, they must take the form of a circle of voussoirs, whose decoration must be treated in accordance with the principles established in treating of keystones of domes.

In ornamental vaults are found several kinds of keystones, subordinated to each other according to rank. The principal keystones, of which each vault perhaps has but one, should possibly be decorated by sculptures, human heads, etc., the inferior keystones by sculptures, Shields, symbols, etc., while those of the third and fourth rank receive rosettes and leaf ornaments.

Both the middle ages and the Renaissance sometimes treated keystones as massive suspended forms, the so-called pendants, that are especially appropriate id the walls must be heavily loaded, when they must seem heavy to the eye, i.e., be massively treated, or when intended to receive chandeliers, when they may have the form of graceful suspended chandeliers.Exaggerations in this direction, i.e., the use of pendants for purposes merely ornamentaland permit their use when without any meaning whatever, is one of the many errors of the later middle ages and must be considered objectionable.

As for the decorative treatment of the surfaces of the compartments, we first have to consider them only so far as then are not plastered and their construction is visible. The earlier

middle ages almost always constructed the compartments of vaults of cut stone, sometimes with unusual dimensions, so that the massive vaults were in condition even to resist the injuries of a fire, but required correspondingly powerful abutments and flying buttresses. The great activity in building during the 12 th and 13 th centuries demanded a rapid mode of constructing buildings, the vaulting demanding a large expenditure of time and money. Hence no attention was paid to the decorative treatment of the compartments of the vaults. It was a toilsmoe labor to prepare the separate stones, which were not very large and were chiefly placed at a considerable distance from the eye of the observer, so that little or nothing was done in a special esthetic treatment of the separate elements of the vault at great cost. Neatness and accorate execution, a soft and yet clear play of light and shade on the surfaces of the vault resulted both from their arrangement and the general plan, remaining during the entire middle ages -- and still remains -- the principal requirements for a pleasing effect of the vaults, which was further heightened by the bond employed, and by the texture of the visible surface and the lines of its joints.

Modern vaulted construction seldom uses cut stone but commonly brick for filling the compartments of vaults; the most natural decorations consist in the formation of a border and in the use of decorative bonds, the more carefully the vaulting is executed, the more pleasing will be the effect obtained; t the moasaic-like joints of brick masonry have an appearance allied to that of textile fabrics, and an analogy in the treatment of vaults thus arises, similar to stretched and freely s suspended tapestries, and to textile fabrics, since all space enclosing masonry recalls the tent roofs, both by its structural bond and by its external surface, which were suspended between pillars for protection from light, wind and weather, against external enemies and inquisitive eyes.

ε. Cloistered vaults.

Not much may be said of cloister vaults not already stated in the preceding discussion of vaults; they are the converse of groin vaults because though produced by the intersection of tunnel vaults, all those parts are retained that are omitted

in groin vaults. At the line of intersection the bond itself forms strong strengthening ribs, so that separate stone ribs are unnecessary, a keystone is required as in domes and ribbed groin vaults, the compartments need the same treatment as in compartment vaults, and cloister vaults on polygonal plans approximate in form to domes, whose decorative treatment they also follow.

c. Renaissance Vaults.

When the Renaissance did not directly employ the Roman or mediaeval vaults then usually ornamented by painting or stucco work, it generally employed low compartment vaults in combination with the so-called Welsh groined vault (Fig. 174), which also offered large surfaces for painting and decoration in relief.

Such compartment vaults, which were mostly vaulted from their angles toward their centres (Fig. 175), are more or less modifications of domes and cloister vaults in combinations with portions of tunnel vaults and may be decorated by the formation of borders, a greater prominence of the centre, or by accenting the transition from one form of vault to another, in accordance with the use of decorative bonds; these accentings may be produced by projecting ribs, which have less structural than a decorative purpose, whose intersections may be enriched by keystones of all kinds. The compartment vaults of this kind are the less suitable for heavy loads, the flatter they are, and are only justified by most careful construction and the use of the best mortar, seldom remaining unplastered, but are principally arranged with a view to decoration by painting and stucco.

To the Renaissance vaults may be added fan vaults derived from ornamental groin vaults, and introduced in the English late Gothic style, though in construction they are more nearly allied to Roman and Renaissance vaults.(Breymann's Constructionslehre). They are strictly combinations of annular surfaces and are therefore bodies of rotation, whose sections may be circular or otherwise, so arranged that the interspaces that exist between their upper bases are either filled by inverted domes, segmental domes, or lastly by pointed vaults (Fig. 177); if the half diagonal be taken as the radius of the vault instead of the half distance between supports, the diagonal sections

of the vault will be circles, and the right sections are pointed arches with crowns lover by the difference between the half diagonal and half span, and from these a sharp and gradually disappearing intersection line of convex curvature rises to t the apex of the vault (Fig. 178); each compartment of the vault borne by one support is in plan a square portion cut from an annular surface of circular section, and these surfaces closely join each other without leaving any gaps between them.

These fan vaults have something very characteristic in their external appearance and vividly recall the leady foliage of the fan palm uniformly spreading outward on all sides, and they m must always be decorated by accenting the horizontal lines in accordance with the horizontal lines of the stone construction. Very pleasing decorative motives are connected with the domical surfaces, used for filling the interspaces between the compartments of the vaults, circular in plan, and the arrangement of semicircular diagonal sections leads to a peculiar treatment of the keystone. Arches are unnecessary in fan vaults, being mostly in disagreement with them; on the other hand constructions in stone are possible, which consist of a series of fan-like ribs connected together, the interspaces being filled with slabs of stone. The English fan vaults of the middle ages are generally based on this structural principle.

C. SUPPORTS BEARING CEILINGS.

I. Columns.

a. General considerations.

In the course of our discussions we have reached a point, which must strongly attract our attention, one on whose solution more or less depends the soundness of our teachings, and which has busied the artistic fancy of all nations and of all periods in a peculiarly high degree, the treatment of columns, their capitals and bases. We cannot introduce and critically examine all the orders of columns in their entirety, that the architectural styles of the past produced, our problem is here only to seek for that generally valid point of view, that may lead us to the form treatment of the columnar order.

The ceilings required supports to receive the load and transfer its downward pressure to the solid foundations: the external walls and the partitions, as well as the columns and piers,

act as such supports. The load always appears very massive and bulky in comparison with the supports, and the idea of weight is always associated with that of bulk; to receive these masses, it is both appropriate and pleasing to enlarge the upper ends of the supports; the load must have a firm support and must be distributed over a large area of the foundation. Hence all architectlural styles characterize by capitals the end of the s supports receiving the load, and generally by bases the end transmitting the pressure to the firm substructure, these intermediate members not only fulfilling the known material purposes, but also characterizing the nature of the supports.

In case of round columns, their capitals and bases are chiefly transition forms so as to change the circular support into the square forms of the abacus and the plinth; they are very commonly fixed endings of limiting forms, and from the vertical position of the supports a distinction is required between the Above and the Beneath, as being ideas of space having unequal values. Therefore all nations have compared the capital to the head of the human form, and the base to its feet.

The differing functions of the upper end of the support, which supports the object in the air or a load, affording it a resting place suited to its form and dimensions, forming a transition to the support, were more or less clearly understood and expressed by different nations, as we found in the Chapter on Limiting Forms, since the idea of supporting something, of detaching it from the ground, is sometimes placed in the foreground, sometimes that of receiving a burden and of resisting the load, lastly sometimes the idea of the crowning of the upper end. As already stated, the lower end of the support was either not characterized at all, as if the support was stuck in the earth like a pile, or it was formed like a cushion or a seat, or even treated like the form of an animal on whose back stood the column. But the supports themselves were regarded as unyielding structural members, and were decorated by parallel vertical stripes; in memory of their original purpose, that of merely serving to support a light tent roof, they were sometimes represented as being wound with tapestries.

These general points of view in regard to the formation of supports were not only those guiding in past times, but are so

still, and will so remain for all future time. Still, they are modified in details according to the different nations, and the circuit of their lives, as well as in accordance with the problem to which they were applied, and the combination of the supports with other architectural details. The different functions of the columns, which restricted their forms within certain limits, are first to be carefully kept separate according to the principle of subordination, if one desires to review the multitude of different forms of columns, that have arisen in all parts of the world. To discover all the ideas which influenced the different peoples in the formation of supports is first of all, entirely impossible.

Why Egyptian columns have their definite form and no other, cannot be explained, but only this may be discerned, that the need clearly existed for characteristically distinguishing the upper from the lower end, that the leaves, stems and flowers of the lotus and papyrus, the symbols of the river Nile, were found suitable for covering the supports of a tent roof, and that the practice of winding tapestry about columns is a very ancient custom. The entire Egyptian architecture creates the impression that the entire building was conceived as an imitation of the tents of the nomadic hordes, which settled in v various places in the then well wooded Egypt, and stuck the supports of their tents in the sand, and the naturalism in the treatment of the coloring permits the conjecture, that the idea of a support, whose capital should express the conflict with a burden, is not a primitive one, but is that of holding up something and of crowning the upper end, as being the head of the column, stand in the first rank in combination with the symbolic ideas not understood by us. That the Doric column has an internal alliance with the Egyptian can scarcely be contested in earnest, as it essentially differs only in the form of the echinus capital, where the idea of receiving the load of the entablature on a special support like a cushion, appears originally to have been expressed by pointed leaves, whose points were recurved downward. Whether this was actually the idea which the Doric capital was intended to personify, or another one unknown to us, can never be decided with absolute certainty. The forms of the row of leaves with recurved points,

which was not only employed as a supporting but also as a separating member in all Grecian architectsre, and in imitation of this in Roman architecture, to formally connect to entirely different objects, appearing from their derivation to be modifications of primitive form elements, such as are likewise represented in the leafy crown of Egyptian capitals, and in the columns of persia and of India, which remind one of fringed spear shafts. Should we desiredto retain these forms of leaf bands for our purposes, it is not historical but practical and technical reasons by which their character will be determined, according as these forms correspond to the convex and concave profiled members, with their attracting, repelling or transition character as separating and supporting members, as band p patterns with a decided prominence of direction, and as enclosing decorations.

A peculiar form of capital, which later found its fullest d development in the Ionic capital, was introduced in western A Asia; the form of a cushion appears to the the motive for all such forms of capitals, this cushion serving to raise the human form above the ground, and which according to its horizontal direction as well as to its upward and downward directions, s supporting the entablature , sometimes assumes the form of a stool, a saddle or a sofa. If the original idea of support was originally identical with that of building up something (which it appears was already expressed in the word Basileos, king, which is from Basis, a support, and Laios, a stone slab, therefore meaning "standing on the stone"), raised above the others, elevated), the idea of generally employing the seat that supported the favored person, as a supporting architectural form, was thoroughly artistic, and one might go farther and conjecture that it was a people in the habit of riding, by whom this idea was expressedl while those unaccustomed to the horse, employed the stone slab or abacus as a bearing member of the capital. Thus we may also see in the representations of vases the Ionic capital with a broad base directly employed as the seat of a figure, just as the form of the Doric capital was used in funerary monuments to support a figure, palm or acroteria.

However the form of the Ionic capital may have originated, its mode of origin, as well as that of the Doric capital, has

its mode of origin, as well as that of the Doric capital, has no significance for our architecture, since the circle of ideas of the ancient vases lies wholly outside the limits of human ideas in general, therefore of those generally valid.

The motive of the capital with two different forms of sides, which reached its highest form in the Ionic capital, will always remain indispensable to the architect, whenever two directions are to be made decidedly prominent in the horizontal plane; in such cases mediaeval architecture did not exclude t the two-sided capital. But if one desires to employ the Ionic capital as the angle column of a building with porticos, which is not in accordance with its nature, he must seek a happier solution, than that found by the greeks for similar buildings, as in case of the temple of Nike Apteros.

We can only designate such unskilful expedients as objectionable errors, as well as those for which the Romans have been so much blamed, and which have been so thoughtlessly imitated in our modern era, that are scarcely better than the aberrations in architectural forms permitted by the late Gothic and the late Renaissance.

As in the older Egyptian capital, the echinus of the Doric capital is merely an undeveloped bell; with it is allied the Corinthian, just as the Egyptian bell capital i to the latter; only the bell capital of the Egyptians is fully developed on all sides, since it has no proper abacus, the Corinthian supports the form of the abacus and is allied to this by its square plan (also if triangular or polygonal), since the most fully developed scrolls and leaves support the angles of the abacus. Two principal forms of flowers, the rosette and the palm, as well as the half developed buds, fill the intervals between leaves and stems, and form the terminal and dividing parts of the stronger branches, while the smaller brarches are dispersed in a free play of lines. The Corinthian capital is no longer, like the Egyptian bell capital, a cluster of similar flowers and leaves bound together, but plant forms grow up around the bell in a manner, which betrays the thorough study of nature by the Greek uculptor; if the bell is largely visible as in the capital of the Tower of Winds, it is closely covered by a row of applied leaves, just as a shirt covers the body, or

the corolla of a flower conceals the stamens. A second row of leaves covers the lower ends of the first; if one row is composed of leaves with smooth edges like the inner row of the capital of the Tower of Winds, or the outer row of the Monument of Lysicrates, as a contrast to these the leaves of the second row are deeply serrate and have deep incisions or leaf eyes, such as are not only found on the acanthus but on many compositae (Onorpodon), for example the thistle, poppy and many umbelliferae (Heracleum) etc. It is very generally the case that no special plant form is imitated in the Corinthian capital, but it borrows special and characteristic parts from the plant world, develops these in accordance with the same laws of growth, as those of actual plants, and thus creates an ideal flora, w whose foliage seeks those parts of the capital, which are geometrically most important, the ends of whose leaves and branches recurve in free growth, or roll up under the abacus, and w whose flowers appear to strive for light just as flowers do in nature. All the separate parts of the completed Grecian Corinthian capital stand in the best relation to each other, but the Roman first ossified and became as if cast in a mould , naturistically swelled and yet dry (Acanthus leaves are never naturally treated in the Grecian capital, this being far from the Greeks, who only employed the typical and not the specific of plants in ornament. The only natural acanthus known to me is found in an early Gothic keystone in Regensburg).

The motive of the Corinthian capital has become so indispensable in architecture, that the middle ages not only used it sometimes, but also even so beautifully developed it, that iu some examples it equals the Greciau capital. (Corinthian capitals from Arles; Schnaase, IV, 490; from Vezelay; Viollet-le-Duc, Dict. Rais. II, 503; from S. Madelaine at Chateaudun; the same; Entretiens, I, Fig. 24).

We may almost say of the Roman capitals, that whatever in t them is good is not new, and whatever is new is not good. The changes made in Grecian architecture by the Romans were without any reference to the original meaning of the forms, with the exception of a conception entirely external, chiefly on practical grounds. The Doric capital is almost the only one in whose transformation an improvement is discerned, it has

indeed become one entirely distinct from the Grecian, and has cast off many peculiarities of the latter, thereby gaining in usability, especially in buildings composed of several stories, where the different orders of columns are arranged above each other.

The so-called Roman composite order, which was developed by combining forms from Ionic and Corinthian capitals for the sake of buildings in several stories and to enrich the repertory of forms; may be justly cast into the historical discard and the gracefully decorated Corinthian capitals of the early Renaissance be employed in its place, which vary the motive of the Corinthian capital with a free play of form. The Tuscan order which the Florentines of the 15 th and 16 th centuries preferred to employ from local predilections, since they held it to be an invention of the ancient Tuscans, the Etruscans, according to the statements of Vitruvius, as well as for practical reasonsbecause as the simplest order, it corresponded well with rusticated architecture, has its justification as a kind of simplified Doric order, or as being the lowest form of a complete order in the classic sense, if we may so speak, though skeptical abou this, although opposed to all the precepts transmitted by Vitruvias and dutifully obeyed by the Renaissance, and we would not employ it merely because the ancients had done so, save only in case it suited our design on grounds of appropriateness and esthetic propriety. The rigid rules of Vitruvius and the whole hocuspocus of antique architectural forms, not only modules and parts, but also triglyphs and metopes, viae and drops, mutules and dentils, egg-and-dart mouldings and cymatiums, etc., belong in the historical discard, as soon as they no longer fulfil any real purpose, and their original sense is mostly unknown to us or does not correspond to our circle of ideas, and has no binding force for us.

Thus on the one hand we have saved sufficient of the classic columnar orders to not ignore them or be compelled to cast them entirely overboard, but on the other hand have sought to free ourselves from their traditional constraints.

No need here exists for troubling ourselves about the merely historically important form wares of the treatment of the early Christian, Byzantine and Mohammedan capitals; only mediaeval

architecture can show new ideas in this direction, which are valueless to us. As stated in the Chapter on Transition Forms, it has preferred to accent the capitals, and the entire treatment of the capital as in the Corinthian preferably consists in decorative coverings of bell forms, in carving low reliefs or convex transition forms like the cushion capital of the Romanesque style, in a combination of both, a favorite feature of the Romanesque style, lastly during the late Gothic in transition forms of all kinds, in which the change from the round column to the square or polygonal abacus does not occur by a regular curve, but by means of various changes of section and modes of corbelling, forms both piquant and pleasing, which are especially justifiable when the purpose must be fulfilled by the simplest means, as in buildings for ordinary purposes, in iron architecture, etc.

Much may be learned from the study of the early Gothic bell capital, which is of value for the treatment of capitals in general, and equally so whether the foliage approximates the acanthus leaf forms or those of our northern flora.

This first completes the division of the masses, most suitable for working out the capital from the rough block, the development of many peculiarities in the foliage itself, based on a very careful observation of nature, the treatment of the bell, to which the foliage is applied, and its connection with the abacus. The mediaeval capital is most completely adapted to v vaulted construction in many respects, and the mode of its formation is better suited to the clustered pier that other forms of capital, and which is required to developed vaulted construction, while the antique forms of capitals correspond to the column as an individual thing, which by its nature can never be halved or quartered so as to be pleasing. Whenever the Renaissance masters have halved or quartered capitals or columns, by one-sided consistency or awkwardness or poverty of ideas, or even treated in the same way their substitutes, the caryatids, as in the late Renaissance, only monsters have resulted, the imitation of these forming one of the many monstrosities of our modern architecture.

The principal gain that we owe to the early Gothic in regard to the treatment of the capital consists in thereby being taught

to make the proportions of height and projection of the capital entirely independent of the diameter of the column, and to place the vaults in harmony with the mass of the pier and with t their loads. The proportions of classic columns harmonize so perfectly with their entablatures, that essential variations therefrom are impossible without injury to the determinate character of the entire order.

Where the height is fixed by the harmony of the entire architecture, it is not possible to firmly adhere to the proportions of the classic orders without having recourse to the expedient of placing them on pedestals, or of being troubled by inconveniences of every kind. Only within the limits of the same architectural problems, which were presented to the classic architect, can the proportions of its orders be strictly retained, and the Renaissance masters have very often found themselves embarrassed in church architecture, not being able to free themselves from the constraint of the antique, but being compelled to arrange the plan to suit the arrangement of the columns, instead of the converse. In such cases one can o only consult mediaeval architecture, to which the constraint of tradition was unknown, but which determined the propostions in accordance with the problem presented for solution, with an artistic feeling as sound as that of the Greeks.

The classic styles almost always striped the shaft of the column with flutes, which enhanced the impression of the rigidity and resistance of the column. These flutes were replaced by gilded stripes in case of columns composed of the nobler kinds of stone, those of metal or those placed in the interiors of apartments; from an esthetic point of view it is very disadvantageous to leave large and massive columns without flutes, since they appear rather heavy, though on the contrary this is well suited to small and slender columns. According to classic ideas columns always require to be diminished upward, both when standing free and when connected with each other.

An enlargement of the shaft is justifiable, as stated in the Chapter of Tectonics on the Forms of uniform Resistance to Pressure, if its own weight and its resistance to crushing must be considered; in the first case its lower diameter should be greatest; in the second the enlargement should be more nearly

at the middle of the shaft.

The massive Doric columns were formed according to the first principle as previously stated, but very tall Corinthian columns usually accord with the second. If very short and thick columns are employed to support massive vaults, whose ribs exert thrusts in many directions, a considerable enlargement of the column appears preferable to none at all. An enlargement is peculiarly justifiable and desirable in case of thin metallic columns exposed to crushing; on the other hand it is nonsense to enlarge columns that do not stand free but are grouped, as done in the late Renaissance and sometimes imitated through modern poverty of ideas. Enlarged pilasters do not belong in the historical discard, but in the museum of human nonsense, that requires to be still more roomy than the former. To this museum we shall likewise have to relegate one of the most favorite blunders, that of rusticated columns, where separate dr drums are treated as rustacated blocks, while their capitals and bases are fully developed. This nonsense, a favorite idea in even the best era of the Renaissance, is modified in various ways;either all the drums of the half columns are rusticated, when they appear as if incrusted with the deposits from a hot spring, or rusticated square blocks alternate with circular d drums, as if the money had been spent in preparing the former, or the drums are all cylindrical, half of them retaining their rustication so as to interrupt the flutes of the column, appearing like rough bands placed around the column. No uncorrupted artistic feeling will deny that the Renaissance masters in the south as well as in the north well understood how to produce a magnificent effect with the means chosen by them, and to obtain good proportions of details and of the whole, which will always continue to be marvellous; but since one may patch up a poem from pompous phrases which remains nonsense, though pleasing to the ear, the worth of architecture lies not merely in its pleasing effect, but also mainly in the choice of means, with the use of motives for determinate purposes, and it must always be considered as being a complete wayt of architectural meaning, to combine architectural motives entirely at pleasure.

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like masonry; it may indeed be hung or would with tapestry as masonry may likewise be movered, and in this way all decorative covering of the column by painting or reliefs is justified; the shaft of the column should be divided into a lesser lower portion and a higher upper part by an intermediate member, either as in colonnades to avoid injuries to the flutes from the passage of men, the lower part of the shaft is left plain or an annular band is interposed, projecting beyond the lower part of the shaft, to make the lower third of the column appear thicker, or lastly to sharply separate the plain or decorated lower portion from the fluted upper part. But to treat a column as if composed of courses of stones is in complete opposition to a true artistic conception, which always considers the column as a unity, indeed composed of parts like the human form, but not produced by the combination of unities.

If we desire to increase the thickness of the wall by rectangular or semicircular projections, a problem very frequently attempted in the late Renaissance, and the treatment is to correspond to the construction of the wall, every reminiscence of the classic column is to be wholly cast aside, and a treatment of the capital is justifiable only in the sense of being a termination to these projections from the wall.

Finally, to treat the columns as twisted elements is always objectionable in architecture, only justifiable and possessing a meaning in art industry as well as in purely ornamental works, in which the supreme principle of weight passes into the background. On the other hand the fluting of the column loses its purpose and meaning in all works of the minor arts, to which also belong the shrines or cases with decorative and symbolic meaning, mentioned in the Chapter of Tectonics on Proportions, whose principal types retain the forms of actual buildings.

The motive of screw-like twisted forms corresponds , as we saw in Tectonics in regard to relative forms, to all combinations of tierods in opposition to parts subject to crushing, as well as to constructions of hollow tubes, which are partly perforated and partly entire, and employed for the most diverse purposes.

There still remains a word to be said in reference to caryatids, atlantes, hermes figures, and whatever else remains in

the service of architecture, from the more or less thoughtful works of classic sculpture, as well as of the mediaeval figure columns, etc.

Whoever uncritically admires everything dome by the Greeks, and wonders at it purely because it was invented by them, will denounce as a heresy the mere question, whether the famous caryatide porch of the Erechteum at Athens is altogether beautiful. Perhaps I may not be the only one, who would hold it to be a Barocco idea however beautiful the columns, if it had no symbolical meaning, and who would feel uypleasantly the execrable disproportion between it and the architecture. There is not merely a want of harmony between the animated figures in contrast with the stiff architecture that they support, but still more in the proportion of the supporting masses to that supported. Had the middle ages ever permitted a canopy to be similarly supported by statues of Christ and the twelve apostles, what a clamor would have been raised over such bad taste. But if we desire to retain the idea and to regard it as original, for the Greeks to employ figures as architectural members, we must still regard this freak as an exception, which acquires no higher value by repetition; besides we should not forget that caryatids and atlantes were used as if set in the pillory or in an even more debased sense, and in this is clearly indicated the limit of the permissible, in the introduction of human figures as architectural members; differently from free sculpture not in the service of architecture, a harmonic union of the plastic arts must be represented in connection with painting and architecture, and the use of the human form as a caricature is indeed justified as a substitute for architectural members if boldly treated; but the contradiction between the movement of human or animal forms and the rigid architectural structure can never be wholly effaced, if these are arranged in any sense other than that of being a decoration of the architecture. Figure decoration of all kinds is doubtless not only appropriate in architecture, but even desirable as being the highest means of ornamentation; but it should not replace architectural details. On the other hand these considerations entirely disappear in the minor arts, for the frequently stated reason that the principle of weight is not there predom-

predominant, which causes in the greater arts and in construction the appearance of rigidity of construction.

The Renaissance architects probably were only acquainted with caryatids and atlantes through Vitruvius, and they created miracles in architecture without the aid of these extreme artistic expedients; on the contrary our era deluges us with figures of sheet metal and plaster of paris, most of which have neither beauty, sense or meaning. These classic heros and demigods are not to be condemned, but should be relegated to the only place to which they are suited, the realm of purely decorative art, the interiors of apartments, for humourous purposes, and lastly to the minor arts.

As we may have seen, the base of the column was considered a base stone, a cushion or a seat, to distribute the pressure of the column ant its load over as large an area of the foundation as possible. Scarcely any other architectural form has become so firmly naturalized and found such wide acceptance as the Attic-Ionic base (Fig. 179). it has always been employed since the most flourishing Greek period until our era, although with many modifications, and the same decorative motive recurs in every style, that of treating its convex torus as a soft and yielding cushion, a row of leaves or a twisted rope, which appears to retain the foot of the column in place. The scotia t that separates the two tori, if properly ornamented, is preferably ornamented by a row of slender leaves.

In the preceding we have briefly considered the treatment of the column according to the ideas of different nations,and in accordance with the problems to which it was applied, as well as its connection with other architectural members. We have to return to the point last named,as supplementary, before taking up the different kinds of columns. The problems for which columns are employed are generally works of architecture, art industry or the minor arts; the first requires the function of support to be strongly expressed, but in the two last this recedes behind other functions. The classic styles introduced in their orders not only different style tendencies but also tones, so to speak, which correspond to the character of a particular building as well as to its different stories, to that of manly strength and dignity in the Doric style, that

of grace and serenity in the Ionic, and of magnificence in the Corinthian.

In accordance with these tones the function of support is more or less strongly expressed in different kinds of columns, so that the character of the treatment of the general mass of a building passes from the grave to the graceful and then to the rich. The conception that the column is to support or elevate an object, the function of bearing then receding into the background, is most strongly expressed in the classic memorial columns and in the rows of columns placed before facades by the Roman and Renaissance architects, and which were crowned by s statues, so that one might well say of these columns that they bore nothing; but to cast them aside for that reason would be to overlook one of their most important functions, and to forget that a large number of Grecian memorial columns would no less be condemned, than many works of Roman and Renaissance.

Memorial columns would likewise have a freer range of form for the reason that being monuments, the function of bearing falls into the background, and since the possibility of ascending to the top of the capital by a winding stairway becomes a principal aim, in a second degree a spiral arrangement of such a column would not only be sensible but indeed becomes requisite, as a ground motive of the manifold structural and decorative compositions that may be derived from it. The idea of a memorial column may thos be developed from the simple funereal monument to the formal tower through an inexhaustible series of possible solutions.

We shall treat of the column in connection with other architectural details in the Chapter discussing the arrangements of columns and piers in combination with entablatures and vaults.

b. Columns in detail.

In regard to the treatment of the separate parts of columns, especially of capitals and forms of shafts and bases, reflections of many kinds may be made on the hypothesis that the classic orders are not accepted as something consecrated by tradition and without criticism as we once did, but that the entire progress of architecture since the classic period, as well as that due to the middle ages and the Renaissance be taken as the starting point or basis of these considerations.

α. Form of the capital.

The most primitive treatment of the capital of the oldest s styles already divided the capital into three parts, the bell, by which we understand in general the concave or convex principal portion of the capital, whether in the form of the Doric echinus or the Corinthian bell, the necking and the abacus. The principal portion of the Doric capital (Fig. 180) consists of the strongly projecting echinus, which well established name we retain as a distinction from other cymas, and this echinus is separated from the shaft of the column by several annulets, or rather the row of leaves painted on the echinus, and which only form a continuation of the flutes as it were, and is closely encircled by these annulets at its beginning like a collar. (Bötticher has made the number of the leaves equal to that of the flutes in his restoration of the painting of the Doric capital, so that as in the Egyptian compound capital the Doric capital and column become a bundle of separate plant stems bound together below the buds). The abacus is square and the circumference of the echinus is inscribed within it (Fig. 181). The breadth of the architrave exceeds the upper diameter of the column on which it rests, but is less than the width of the abacus, so that the latter and the echinus are in part not loaded. (Fig. 182). The architrave does not lie directly on the abacus but only apparently, since an imperceptibly raised central portion is left to receive the architrave, so that the angles of the capital are not loaded (Fig.183).

Some capitals like those of the temple at Paestum have a second row of leaves beneath the neck bands, whose points are slightly recurved. If the architrave were laid directly on the abacus, the capital would be unsymettrically loaded, and the excessively projecting angles of the abacus would run some risk of being broken off.

The Roman Doric capitals, which were perhaps imitated from late Grecian examples no longer existing, more freely represent the ground idea of the Grecian Doric archaic capital, retaining the adopted motive though without strictly adhering to its form, and vary the theme in manifold ways. the Renaissance followed this Roman mode of treatment, sometimes mixing forms resembling Ionic and Corinthian with the Doric.

The first essential alteration of the Doric capital by the Romans consisted in lessening its projection, giving to the architrave a breadth only equal to the upper diameter of the column; consequently the echinus became of smaller importance, so that its section approximated a quadrant, and the smaller projection of the capital required compensation in its increased height or that of its necking, so that the mass of the capital should not be dimnished too much in proportion to the column. The neck was then separated from the shaft of the column bya bolder member, an astragal with a small fillet or a pearl bead, and was decorated by rosettes, palms, etc., and the abacus was ornamented by a row of leaves or a cyma. Besides the normal capital, two other very fine forms of capitals have remained to us, one from Pompeii and the other from the baths of Diocletian (Fig. 184); the necking of the first is a flat curve, while the cyma of the other is not formed like an echinus, but is composed of vertical leaves. Several kinds of capitals may be formed of a combination of forms taken from different capitals with the aid of two rows of leaves, which are suited to the most diverse problems bu their greater or lesser height, but which lie within the limits of the motive established by the Roman Doric capital.

The Tuscan capital (Fig. 185) restored in accordance with t the statements of Vitruvius is nothing more than a simplified Roman Doric form, just as the entire Tuscan order is merely a reduction of a classic columnar order to the most indispensable motives. This order was much used in the early Renaissance as better harmonizing with rusticated masonry, and in combination with that it is especially adapted to fortifications and engineering structures, city gates, barracks, and in general to massive structures for ordinary purposes.

The abacus of the Dorci capital projects at its angles considerably beyond the echinus, so that its underside becomes visible; the Romans decorated this lower surface by recesses but thereby weakened the angles already in danger of breaking under the load. If the abacus were made octagonal these angles disappear, but the character of the capital is changed and it would appear compressed, only adapted to receive an impost of the s same polygonal form. The angles of the abacus might by lessened

by making the diameter of the echinus equal to the side of the upper part of the abacus, but so profiling the edge of the abacus that its square under side would be circumscribed by the circumference of the echinus. The abacus then loses its meaning as a covering block and assumes the character of a peculiar support on which rests the load (Fig. 186); the underside of this support must then be octagonal passing from the octagon into a square form at top. All these forms of the abacus have their meaning, especially in case the capital is intended to receive vaults or arches, when a broad mass is placed on aproportionally thin support; this is especially true of iron architecture and of iron columns supporting vaults.

Finally one means for supporting the angles of the abacus consists in employing some decorative motive on the capital a after the precedent of the Renaissance, to fill the space between the echinus and the angles of the abacus; the Renaissance used for this purpose small heads of animals and men, decorated the capital by dolphins or cornucopias, garlands of flowers or clasp-like volutes, etc., according to the use of the capital in structures more or less richly decorated.

Roman and Renaissance architecture almost always crowned the abacus by a row of small leaves (Bötticher calls this a lesbian cyma); the profile of the abacus is varied in different ways,, (Fig. 187), according to the projection desired, which in this case results intirely from the geometrical construction of a circle with inscribed and circumscribed squares, in which it is desired to avoid a projection of the abacus beyond the echinus; the use of the capital for a special purpose, or the material in which it is executed will decide the choice of a profile for the abacus, since any particular profile gives to the capital a peculiar character.

The annulets that separate the echinus from the necking were either treated by Renaissance architects in accordance with t the precedent of the capital from the theatre of Marcellus as simple fillets, or as beaded astragals, astragals with fillets, and even as a lesbian cyma by Scamozzi (Fig. 188).

The neck of the column may be straight or concave as already stated, or be changed into a second row of leaves like the capital from Paestum, or finally it may be left straight and dec-

decorated by rosettes or palm leaves; in Roman and Renaissance architecture it is almost always separated from the shaft of the column itself by an astragal and fillet, instead of which other mouldings may be introduced according to circumstances, a favorite idea in the middle ages (Fig. 189).

The idea of the Doric capital may be developed in the most diverse ways as we have proved, and the general ground laws concerning form and purpose, material and preparation, light and shade, etca, require these forms and their modifications.

The classic columnar orders were devised for post and lintel construction; when these were combined with vaulted construction by the Romans, a very troublesome anconvenience was caused thereby. If the columns were connected by an architrave and a arches were thrown across above this, the architrave was not loaded and so became unnecessary; it it was omitted in the interior of a building but retained on the walls, the columns intended to receive the arches were either higher than those attached to the walls (Fig. 190), or the arch sequired to be stilted; both arrangements possessed unpleasing peculiarities.

Roman and Renaissance architects hit on a truly consistent though unmeaning expedient, that of placing above the capital a fragment of the architrave square in plan, or sometimes a part of the compete entablature with its frieze and cornice. Aside from the fact that such a block of the architrave or entablature is without meaning, when the column and the lower part of the vaults are viewed diagonally its mass appears ungraceful, heavy and unpleasing, and this impression becomes still more unpleasant if the capital is of the graceful Corinthian type. The Grecian Dorci capital is the least ungraceful, its widely projecting and strong echinus supports very well a broad mass; but the severity of the Grecian Doric order is more decidedly opposed to the entablature block, than the more pliant forms of Roman architecture.

To load the imposts of arches and vaults directly on the capitals as sometimes done in early Christian architecture , and which modern architecture likewise allows, appears most unfavorably in case of free columns. The masses of the vault widening upward from the imposts require an energetic preparation, and both the classic and Renaissance styles know no other means

of obtaining this, than by the awkward entablature block.

Byzantine architecture made a virtue of necessity by inserting an inverted square pyramid of the desired height between the capital and the lower part of the vault, likewise making it very heavy in form. Yet in this ugly block never made beautiful by the richest decoration, a motive was introduced capable of being developed in another way; it is a support inserted between the capital and the vault, which can itself be entirely free from the forms of the architrave, and may receive a different form in accordance with the special problem in which the columns and arches are employed. According to whether the arch or vault requires a larger or smaller support between its lower portion and the capital, this support will consist of one or several layers, whose differences of section are to be arranged in accordance with the difference of the sections of the column and the impost, and the most pleasing proportion of the masses.

The support may be crowned by a row of leaves or a cymatium with the greatest propriety, and may be treated as a plain block, be flat, concave, with rosettes, ornaments, decorated necking, etc., or lastly be treated as a swelled cushion, and it can form the transition from the round column to the square impost block, in brief it may play the part of an intermediate support in the most varied way.(Fig. 191). Mediaeval architecure made the richest use od this stool-like intermediate support in accordance with the need of raising the base of the pier or column. Even the French and German Renaissance sometimes introduced this support, or employed the classic entablature block, changed by the omission of the architrave.

If a form of architrave remains on the walls of the interior and also in other places, it is evident that the addition of this form of support is unnecessary; but it is always desirable to place the arches on the columns so as to connect the mass of the impost with that of the capital, and to have the support consist of a single low course of stone. The support cannot be omitted in case of coupled columns, but columns attached to and projecting from the wall need to retain their form of architrave in case the engaged column pe not omitted, for there is an essential difference between a broken cornice and an entablature

block in the classic style. For clustered wall culmns the broen cornice always has an effect as a mass, less unpleasant than the entablature block over detached columns; if the columns and capitals are entirely free from the walls, with a broken cornice seen in the most unpleasing way, i.e., viewed diagonally, the mass resting on the capital will still be less, than in case of a column standing entirely free on all sides; this mass may properly be lessened by not allowing the geison with its crown moulding or cyma to project more than is absolutely necessaryat the places where the architrave and frieze are broken, while it may project elsewhere as much as may be required (Fig. 192); for its chief purpose is to protect the building from the rain water running downward, and its protection cannot be received by a column detached from the walls, unless the geison projects on all side like an umbrella, which would be very ugly. In drawing columns with the masses supported by them, it is absolutely necessary to represent the object from the most unfavorable point of view, or to draw a diagonal view in order to decide on the projections and divisions of the mass by the pleasing effect of the proportions to be obtained, as well as in all objects in which one form of section passes into another, for example a circle into a skuare; perspective drawing is not alone sufficient to give a proper idea of these proportions. This is especially true in case not only the effect of the mass, but also that of the outlines is to be considered, as in monuments, memorial columns, church towers, etc., since it then becomes necessary to draw a view parallel to the diagonal of the octagon e f (Fig. 193), as well as a front view a b and a diagonal one c d, in case a transition occurs from the square to the octagon.

The two-sided Ionic capital, whose mode of origin remains as obscure as that of the Grecian Doric in spite of all acute researches, differs in principle from the Roman Doric capital, strictly speaking, only in that the characteristic volute cushion is inserted between the abacus and the echinus. The proportions of the different parts are evidently different in the I Ionic capital from those of the Roman Doric, and the individual motives likewise have forms differing from those of the latter, yet the ground ideas are the same with forms only approximately

similar. The prototype of both capitals appears to be traced to a column originating in the island of Samos, whose capital shows the Roman echinus decorated by leaves, but without the Ionic volutes. (Chipiez. Hist. Crit. des Ordres Grecs, p.266). The abacus of the Ionic capital merely consists of an Ionic cymatium (erroneously termed egg-and-dart moulding) or a lesbian cyma, the necking of the column is omitted or is decorated like that od the Roman Doric capital with palm leaves, rosettes and similar ornamental forms, according as the capital requires a lesser or greater height. The cushion is treated in various ways; these are referred first to the front view of the volutes with their eyes, then to the side view. The Roman and Renaissance architects really understood how to make the form of the Ionic capital beautiful, although one must admit, that the Renaissance strained every nerve at least to perfect the proportions od its Ionic capitals. The reason of this lies in the fact that neither the Roman nor the Renaissance masters were acquainted with the more perfect Greciau Ionic capitals. In the most beautiful Ionic capitals, for example those of the Propyleum at Eleusis, the cushion is highest at its middle, a and its section diminishes toward the eyes of the volutes; its front surface is flat with an enclosing border.

On other capitals as in those at Eleusis, the falt surface is treated as a hollow, and on the capitals of the Erechtheum at Athens the entire cushion is treated like two bards placed over each other, and hollowed out on the front surface. The angles between the cushion and the Ionic cyma (egg-and-dart moulding) are sometimes filled by palm leaves. In the more beautiful capitals the volutes make but two complete spiral t turns around the eye; in the doubled cushions of the Erechtheum a not very pleasing duplicate of the motive is produced by the double cushion. The capital from the temple of Apollo at Bassae is abnormal in a twofold sense, for it has cushions on all four sides, their centres being occupied by vertical palm leaves.

The later capitals were followed by the Roman and through by the Renaissance architects, and treat the cushion as a mere band with a border on its upper edge alone, no thicker at the middle than at the sides; the capital thereby becomes lower as a whole, which may be desirable in many cases, but the cush-

cushion loses its distinctive character.

On the contrary by treating the cushion as a double band, the turns of the volute having free scope, the volute as well as the entire capital becomes high, so that a necking becomes necessary to separate it from the shaft as in the Erechtheum at Athens. The Renaissance architects sometimes decorated the face of the capital by acanthus ornaments and gave the eyes t the form of rosettes.

The facts here stated are evidently only reminiscences: the detailed treatment of the capitals must always iu reality be based on a careful study of the classic columrar orders, and requires the most careful consideration of new ideas.

The side view of the cushion is always formed as if firmly bound together by a band, but the volutes are freely developed on both sides: several pearl beads sometimes accompany this band,as on the capitals of the Erechtheum, the side of the cushion is generally covered by scale-like lancet or acanthus leaves, or is even decorated by free scrool work. (Fig. 194).

One of the oldest Corinthian capitals with a double row of leaves, that of the tower of the winds, even has a square abacus; the later capitals as already stated sought to support the angles of the abacus by leaves or scrolls. The square abacus has too heavy an effect in proportion to the graceful foliage of the capital, and therefore a slightly curved form was given to that of the temple of Apollo at Miletus and elsewhere; but since very acute angles were produced by this curvature, easily broken off by the load, these were cut off so that the abacus formed a square in ground plan with curved sides (Fig.195)

The centre flowers of palm leaves do not project in plan beyond the angles of the square, so as not to unnecessarily increase the dimensions of the block required. If the centre flower is to be covered by the abacus, its edge curves outward at both the angles and the centre (Fig. 196). These two forms of the abacus were first employed on the capitals of the monument of Lysicrates and on an ante capital from Eleusis. The profile of the Corinthian abacus remains a slightly or strongly coved slab in Grecian, Roman and Renaissance architecture, and is crowned by the Ionic cymatium; the astragal that separates the capital from the shaft remains in all these styles with the

form of a plain or beaded astragal connected with the shaft by a fillet and a transition form or cove. This abacus is sometimes decorated in the richer Roman examples by a running ornament or by vertical leaves, the so-called pipes.

As already stated, the Renaissance introduced a freer form of capital like Corinthian, which even more than that bears a purely decorative character, and that was transformed in the most varied ways to accord with the most manifold problems. Mediaeval architecture has done nothing in any way for the treatment of the capital on the Corinthian principle; it first separated the abacus from the capital in many cases, even for practical reasons, since the bell of the capital was the work of the sculptor, while the abacus was that of the stonecutter when not decorated; consequently the bell itself was finished by a slab, which was circular, square or concave, as in the abacus of the Corinthian capital already mentioned, according to the arrangement of the capital. The abacus placed above the bell block could then be square or be adapted to the impost of the arch, sometimes polygonal or circular, or it could take a form composed of polygonal, circular and rectangular elements. The mediaeval Corinthian capital also received a second innovation for practical reasons, which is worthy of imitation in many cases; in case it is not wrought from a single block, but is composed of two layers of stone, each of the two rows of leaves has its own bell slab, so that the lower bell does not appear so much dismembered as in many larger Corinthian classic capitals.

Gothic architecture frequently developed the abacus in accordance with the principle stated in the preceding, as a kind of support, whose base was set so far behind the greatest diameter of the capital as to avoid any projection of the support beyond the bell. In mediaeval vaulted construction, the angle leaves and buds of the capital appear less like organic parts of the capital bent downward by the load, or whose upward growth is hindered by the abacus, than as parts which indicate t the direction of the ribs of the vault, even in the capital, o or as light garlands, which seem to have sprung from the fully organized structural mass as a necessary expression of its natur

Just as the Ionic capital accents two directions, mediaeval

architecture introduced the motivo of grouped corbels to emphasize the direction, and which are supported by a separate capital or spring directly from the support, can bear an entablature or the springing block of several arches, and not only clearly indicate the directions but also lessen the spans (Fig. 198). The Renaissance fterwards took up this happy motive and sometimes treated it in the most graceful way in accordance with classic decorative principles. Heads, acanthus leaves and other forms borrowed from classic modillions may be applied to such corbel forms as ornaments, and decoratively personify their purpose.

β. Form of the shaft.

We can be explicit in regard to the detailed treatment of t the shaft of the column; Doric columns always have intersecting flutes of flat curvature in section, terminated at top and bottom in any suitable way, while the flutes of Ionic and Corinthian columns are always separated by fillets and have semicircor or elliptical sections, and the latter sometimes end at top in a row of lightly recurved leaves. If the column is divided in its lower third, this is either done by a broad band, that appears to be connected to the shaft by small mouldings on its edges,or by a bold annular moulding; in the first case the projections of the small mouldings, whether astragals or pearl beads with fillets, should not extend beyond the lower diameter of the column, so as to be suited to the uncut blocks. On the other hand strongly projecting annular mouldings, favorite forms in mediaeval architecture, signify that the column is composed of three pieces, when they are wrought from separate blocks of stone. The profiles of such annular mouldings, which seem to personify a powerful swelling of the shaft by means of its own impulse and strength, may be formed in various ways, in accordance with the purpose, the material, the proportions and the decoration intended (Fig. 199); whatever the form of profile, height or character of lightness or heaviness, it is given to them depends on special circumstances, and also on the amount and quality of the decoration, which may be represented by a row of leaves or flowers, a rope wound around the column, a band set with semi-precious stones, or a band with heads or hooks for suspending garlands, etc.

A broad band wound around the column may be decorated by any

band pattern as an ornament in rich decorative works, and the shaft itself be covered by all kinds of ornamentsin color or relief, scale-like, carvings like tapestry, network, scrolls or suspended ribbons, garlands and symbolical accessories, which conceal the nucleus of the column. According to the tendency of the free and rich ornamentation, we must always ask t the aid of the Renaissance, which was fruitful in an inexhaustible wealth of the most beautiful decorative ideas. Even the northern, French, Dutch and German Renaissance afford many specimens of beautifully decorated shafts of columns.

γ. Bases of columns.

The simplest form of the base of the column is that of the Tuscan order, which merely consists of a torus or of a base moulding instead of the torus, the plinth and a fillet with a cove, which forms the transition to the shaft (Fig. 200). The richer Attic-ionic and Corinthian bases have maintained themselves in the Renaissance as normal profiles after the Roman type and could now be scarcely displaced (Fig. 201). They fulfil their purpose as a base for the column in the best way, and are readily decorated by ornamental elements, which represent the fixedness of the column in its position, and the yielding quality of the cushion placed beneath it in the form of small mouldings, cushions and rows of leaves.

The true forms of Ionic bases from Asia Minor have scarcely any importance for northern architecture in their peculiar proportions and forms, but on the other hand different variations of the profile of the base have meaning and justification and may be developed partly by their simplification or enrichment, partly by increasing or diminishing their projections and heights (Fig. 202). These modifications of the profile of the base chiefly depend on the position of the eye of the observer, according to which columns placed high above the eye require a high base on account of their perspective foreshortening, and on the contrary the base may be low when viewed from above in the direction a(Fig. 203) would appear quite differently from that seen from below in the direction b.

Just as the angles of the abacus of the Doric capital overhang the echinus, so as to produce danger of their being broken off by an unequal load, a vacant space remains between the low-

torus and the angles of the plinth in the normal classic base, so that one might fear the flushing of the angles. Mediaeval architecture filled these gaps in a thoroughly natural way by corner leaves, or sought to reduce them in various ways, either by hollowing out the upper edego of the plinth, by cutting off its angles, or by increasing the diameter of the lowest torus, so that its circumference became the dircumscribed circle of the square plinth; or lastly by combinations of these different modes of arrangement, as well as by hollowing out the angles. (Figs. 204, 205). If the diameter of the torus exceeded that of the plinth, the overhanging torus required support, which was furnished by a small corbel or an ornament. All these detail motives introduced into the forms of the base by mediaeval architecture, at least in part, may well be clothed by the forms of the Renaissance. A peculiar treatment of t the bases of columns corresponding to the capitals composed of forms placed diagonally in combination with others, whose changes of section do not occur gradually, but suddenly, was a great favorite in later mediaeval architecture and thereby created a motive, which may be employed in many cases, very suitable for casting metal, iron architecture and wood carving.

5. Pedestal of the column.

Roman architecture and following it the Renaissance felt a natural necessity of introducing other features in addition to the normal ones of the orders, which should be more perfectly adapted to the treatmen of buildings in several stories; if one desired to place one order above another, the great projection of the lower entablature concealed the bases of the columns placed on it. Perhaps the windows that were introduced required a fixed height of the wall between them and the cornice; to make the base of the column visible, it could be placed on a separate pedestal of the same height as the window sill (Fig. 206). But this with its cap must now find room between the base and the top of the cornice in accordance with the tolerably normal proportions of the orders, which varied within certain limits, the diameter of the column, its height, etc., were the dimensions fixed in advance, the scale of the upper story was entirely determinate, on which those of the lower stories were dependent with their heavier orders. This scale of the lower story made necessary the insertion of a pedestal under its

columns, which would otherwise have borne false proportions. Peculiar forms of pedestals were in this way developed for the orders, which require consideration in detail. The height of t these pedestals amounts to perhaps 1/9 to 1/5 that of the entire story, or about 1/3 that of the column with its capital and base' the breadth of the pedestal, which supports the base of the column, should not be much less than that of the plinth of the base, since this would appear otherwise as not sufficiently supported, that is always disagreeable.

The simplest form of pedestal consists of a die, cap and projecting base; the cap may be connected with the die by supporting and transition mouldings, according to the purpose for which the pedestal is employed, and in accordance with the richness of the architecture, and the die may likewise be connected with the base by an apophyge (Fig. 207).

The Renaissance masters kept their orders strictly separate, and gave these simple forms to the pedestals of the Tuscan columns, more richly profiled cap and base to the Doric, still r richer ones sometimes decorated to the Ionic and Corinthian, in accordance with the precedents of classic pedestals (Figs. 208, 208a); a separate necking was also sometimes used as by Vignola. As a rule the band is the principal member of the cap, though this is sometimes the transition member (cyma, corona) as on the arch of Constantine and that of Severus.

The richest form of pedestal was invented for the so-called Composite order produced by a combination of Ionic and Corinthian. Although the Composite capital as being a monster has no importance for us, and the essestial differences between the entablatures of the Corinthian and Composite orders consist o only in the use of both modillions and dentils, which after all is not great, we shall not be afraid to borrow the richer forms of the Composite pedestal when they have any value to us.(Fig.209

Pedestals have an importance as a basis for free standing m monuments on which something is to be placed, even greater than for columns. They then become columns or supports bearing an object in the air, and from that point of view both the classic and Renaissance styles employed pedestals for columns, and furnished them with bases and crowning caps. We shall hereafter consider the pedestal of a monument by itself.

In massive arrangements of piers, such as are required by vaulted structures, especially in mediaeval church construction, the bases of clustered piers and columns should be treated as massive base blocks, which with a gradual increase in width, distribute the pressure of the pier over the foundation. The offsets of the courses should be softened by any transition forms; the lower course could sometimes be shaped as a bench for a seat (Fig. 210); where such a seat is useful and justifiable, it affords the best means for giving the pedestal a broad base.

2. The Pier.

Generally by the word pier are understood so many different things, that it is scarcely possible to give an exact definition of the conception; therefore we shall here only apply the term to those vertical supports which are not columns, both detached and connected to walls.

α. Treatment of the pier in the Classic and Renaissance Orders.

Piers in architecture always have this in common with columns, that of being intended to support a load in the air, and to t transmit the pressure to the foundation; like columns they require a base slab, base, abacus and capital. As in case of columns, capitals and bases have the function of forming a transition between the form of the pier and those of the load and the foundation; but since the section of the pier is almost invariably formed with reference to the architectual details nearest it, the formation of the bases and capitals of the piers is s simplified.

The classic orders were generally only concerned with square detached or compound piers. The Grecian Doric style gave wall piers an abacus supported by a Doric and half recurved row of leaves (cymatium) and finished at top by a small crowning moulding; the cymatium (hawksbill moulding) was connected with the pier by a necking or a few bands, or exceptionally by an Ionic cyma supported by a pearl bead (Fig. 214), as on the temple of Nemesis at Rhamnus. The base consisted of a simple projecting plinth or a reversed base moulding. Small modifications in the forms of these capitals evidently occur in the few examples remaining, and each individual case is designed in harmony with

the entire building in which it is found.

The pier caps of the Tuscan order of the Renaissance masters are partly very simple as in Vignola, partly richer and so profiled that the crown moulding becomes predominant (Fig. 212). The Roman and Renaissance styles profiled the Doric pier capitals in very similar ways, but usually left the base entirely simple, which consisted of a single offset with or without a transition moulding.

The Grecian Ionic order invented two characteristic forms of anta capitals in the most important examples remaining from t the Erechtheum at Athens and the temple on the Illissus at the same place; further in the Propyleum at the temple of Minerva Polias at Priene, as well as in the temple of Apollo Didymaeus at Miletus. The two first consist of a bead and necking between which were inserted an Ionic cyma with above this a lesbian cyma with a pearl bead (Fig. 213). The necking was decorated by palm leaves, and in the first case was separated from the shaft by a small pearl bead. The two last are the so-called c canopy capitals (Mauch. Arch. Ord. Pls. 11, 12), but to approve their form as well as their unquiet decorations, one must be a blind enthusiast for Grecian antiquity. The Grecian Ionic s style forms the base of the pier like that of the column.

The Roman Ionic style, and in connection with it the Renaissance treats the capitals of piers as richly moulded abacuses, with almost entire independence from the Greek conception, or as a capital decorated by foliage. What now remains of Roman architecture in general possesses so little authority over detail, that a great number of these heaped mouldings of caps have little value to us, and we can more nearly follow the Renaissance, which took the greatest pains to restore the ideal of Roman architecture with whose decadence it was principally acquainted (Fig. 214).

Two versions of pier capitals of the Grecian Corinthian style are known to us as in case of the Ionic, the pier caps from t the tower of the winds at Athens and two beautiful capitals from the entrance hall at Eleusis and from Paestum; both have decorations of foliage and figures. (Mauch. Arch.Ord. Pls.13,15).

The Romans almost wholly employed only the Corinthian bell capital with acanthus foliage, which was adapted to the rectangular section of the pier; the Renaissance masters used similar

forms, or impost capitals in case of piers supporting arches, which differ little from those of their Ionic or Composite order, chiefly in possessing a richer ornamental decoration than that of the latter (Figs. 215, 216).

The bases of small piers such as window pilasters or those employed near canopied niches, were more simply formed in Roman and Renaissance architecture according to cirmucstances, a and the mouldings were reduced to their possible minimum, or on the one hand if the decorative treatment was refined in accordance with the material used (marble, bronze) and the position of the little piers or columns, the surfaces of the pilasters were decorated by delicate ornamental work or inlaid work, small columns were even treated as graceful candelabra, which is entirely justifiable and especially in decorative works.The forms of such minor architecture are of importance in the composition of monuments proper, reredoses and similar articles of furniture related to the domain of architecture proper, as well as actual furniture. In art works on the other hand, according to the principle firmly retained throughout our entire discussion, in general only the typical in architectural forms possesses meaning, while the detail forms require transformation and a finer treatment, corresponding to the purpose of the furniture and other articles.

β. Formation of compound piers according to the classic plan

According to the plan of an interior, a series of modes of forming groups of piers result, which may be referred to a few ground motives:- 1, two or more piers form a group of elements of equal height; 2, they form a group of elements of unequal height (Fig. 217). In both cases the following ground motives result in practice:- a, two piers stand beside each other; b, two piers make a right, acute or obtuse angle with each other; c, several piers compose a group. These problems occur on facades as well as in interiors, in post and lintel as in arched construction.

If several piers are connected in a group of determinate height, each one either requires its separate capital and base, and the piers may then be detached from the wall, which affords sufficient space for the free development of the capitals and bases, a common plinth and abacus may also be added to these;

or the capitals and bases grow together and form a compound c capital anf a compound base, in which reentrant or projecting angles sometimes require transition ornaments to fill the angles, so that the group really forms a whole, and does not appear merely as an external combination.

Transverse connections are not only proper, but are necessary in many cases in compound piers at about one third or one half their height, in order to properly bond together the different courses of stone, each composed of several pieces; this is especially true of brick piers where a bond stone must be inserted occasionally. One of the finest examples of transverse connections is found at the angles of the court of the Cancellaria at Rome. If the piers of a group are of unejual height, two cases become possible, the capitals and bases of the projecting portion extend around the other (Fig. 218 a); or the pier caps and bases of the receding portion die against the p projection a. The projections of the cap and the projection of the pier must be so arranged, that this dieing of the mouldings is possible (Fig. 219). Since the cap of the lower pier must be included within the solid of the projecting one, the cap of the former may extend entirely through the pier as a course of stone, breakink the projecting portion as a band. But this band man remain plain; or the lower mouldings may be broken around the central pier, supporting a smooth projecting band, against which the upper mouldings die; or the upper mouldings may extend through and only the lower ones die against the central pier; or lastly the entire cap moulding may be broken around the central pier (Fig. 220). If capitals are found at three different heights in a compound pier, one should take care that the cap of the lower pier dies against the projection of the highest one (Fig. 221), and the courses which correspond to t these capitals could only break the higher pier as smooth bands in this case; any other arrangement would have an effect more or less disturbing.

Compound piers may cause the disadvantage of occupying more space as well as obstructing the view, and of hindering the passage of light into the room. The separate piers may therefore be in part replaced by columns (Fig. 217 a). This causes many difficulties; one must first decide whether he will strictly

adhere to the principle of considering the column only as a unit, therefore never employing it asa quarter, half or three quarter column, nr whether these shall be used. If it is decided to substitute columns for piers, that never require a fixed ratio of heidht to width, one is always fettered by proportions to a certain degree, and if he refuses to make the ratio of height independent by placing pedestals beneath the columns, it may occur that the columns will appear too slender in comparison with the remainder of the pier not replaced by columns. If different heights in the compound pier are to be taken into account, another proportion of the column must be suited, and it would be very difficult to obtain a harmony of all parts. These and other difficulties that especially occur in church construction, will not be diminished but even increased by the use of half columns, formed according to the classic model, and one can only avoid them all by emaocipating himself from the classic orders and strengthening the pier by semicircular projections, which are entirely independent of all classic proportions and are provided with capitals especially composed for each case (Fig. 222). In this way is found the mode of formation of piers employed in mediaeval vaulted construction, one tendency of which was begun in the cathedral of Autun and never received any farther development; or was brought to a consistent issue, although a kind of Renaissance was created in it, which is as far removed from the coercion of the classic as from that of mediaeval architecture, or from Gothic, the most extreme phase of its development.

γ. Compound piers according to the mediaeval plan.

The question arises how the problem of mediaeval vaulted construction may be solved by a treatment of the piers, that may retain whatever is worthy to be retained, of the forms of classic architecture and in the spirit of the Renaissance, but which is freed from the restraint of the classic orders, so f far as their rules cannot now satisfy purposes for which they were not intended. Take the general case of a space to be divided by piers, each bay of the plan to be covered by a groin vault, with the further condition that the pier must occupy as little space as possible, the ribs and arches of the vaults to be entirely separate at the imposts and not intersecting;

if we support the side arches by semicircular projections, the total width of the piers will not be less, than if these projections were rectangular; the supports of the ribs would appear too massive in proportion to the ribs if rectangular, when viewed diagonally, for the moulded ribs would then recede back of the supporting pier. Therefore we can make the projections rectangular under the side arches and round under the ribs, thereby obtaining arrangements allied in form to the transition style, the more readily if we make the crowns of the arches of approximately equal heights, which requires different heights for the springing points of the supports. The rectangular pier should be treated similarly to classic pilasters, but the semicircular piers supporting the ribs are not considered as being classic columns, since their proportions are entirely independent from those of columns; they are and remain round piers or vaulting shafts, to use the striking expression of the middle ages.

It is here sufficient here to have indicated in what way the mediaeval form of pier may be adapted to one allied to the classsci type and conversely; this is not the place to go onto separate questions concerning the treatment of the pier, which results from mediaeval vaulted construction; whoever fully understands mediaeval architecture will easily find his way in accordance with what is given here, to compare mediaeval and Renaissance modes of treating the pier. There only remains for consideration the problem of reducing the section of the pier to occupy the least possible space and not obstruct the light.

If the pier, or rather the section of its load, be arranged symmetrically about two axes, it may be replaced by a simple cylindrical column, if its capital be so formed as to afford a proper support for each separate arch. If the symmetry exists only about a sin le axis, the support may be a pair of equal or unequal coupled columns, or may consist of a group of round columns, according to circumstances (Fig. 224), in which case it must be remembered, that in most cases it is very difficult to transmit a uniform pressure; or one proportional to the sectional areas of the different columns, and that generally but one column really supports the load, the other being slightly loaded or not at all. Round pillars neither require to be swelled,

diminished, nor fluted, as they are not columns in the sense of classic columns of fixed proportions, but are rather circular wall masses, if one may so speak. In all forms of piers cited heretofore, we have assumed that the side arches and ribs are separated above the capital, so that the section of the impost block is not composed of arch and rib sections interaceting each other. The reduction of the section of the pier to its minimum depends on the formation of the impost stone, neglecting the strength of the materials employed for the pier, and the permanent crushing load on the pier. While the mode of executing a refined and complex piece of stonecutting was not yet understood, the ribs and arches were necessarily separated from each other above the impost cap of the pier. in the best Gothic period it first became known, how to allow the arches to intersect at their lower ends, to require the least possible area on their support. Then three cases became posseble, either the extreme outer points of the ribs and arches were equidistant from the axis of the pier, or the arches or else the ribs projected more than the other members (Fig. 225).

The simplest arrangement in both appearance and execution is that in which the ribs and arches unite above the impost and form a polygonal impost (Fig. 226), which shows the section b reduced to its minimum. If the ribs are smaller than the arches, the polygon has alternately equal sides c, and since each stone above the impost is to be wrought from a rough square block, to save material it is preferable to keep the number of courses of stone between the impost and the first voussoirs of the ribs and arches as small as possible, and to allow the ribs ho project so far from the axis of the pier, that their sections may completely fill the upper square a b c d of the rough block a b c d e f g h (Fig. 227); in this case the cap stone of the pier will be square. If it is desired to have the ribs and arches project as little as possible, to reduce the support to the absolute minimum, they should spring from a square capital as in Fig. 228); but if we wish to separately develop the arches, reducing only the ribs, the abacus of the capital might be square (Fig. 229). To place the most distant parts of the ribs farther from the axis of the pier than those of the arches would be incorrect; not forgetting the case when the ribs and

arches have equal radii and equal heights of imposts and crowns in a vault on a square plan. A peculiar form of vaulted construction would then be developed with very high sections of ribs, cross-shaped and strongly projecting capitals that should be treated as corbels if they are to be placed on small supports; such constructions are suitable for mixed iron and stone construction.

3. Entablatures of Stone, Wood or Iron.

α. Treatment of entablatures.

The most important points concerning beams of wood and stone have been stated in connection with the treatment of ceilings, yet these have been given with special reference to interiors, less to the development of entablatures on the exterior and s serving to connect supports, either columns or pilasters.

The bearing capicity of entablatures increases in proportion to the square of their depths and in direct proportion to their widths, as well known; the spans of intercolumniations then depends on the sectional area of the entablature, but evidently chiefly on its resistance to transverse stress for the material employed.

Classic styles treated the architrave as a simple beam with a projecting margin (Fig. 230), or it was composed of two or three courses lying on each other and crowned by a cymatium, the courses being separated by richer arrangements of pearl b beads or smaller cymas. The underside of the architrave remained smooth and was decorated by painted band patterns, but in Roman buildings it was generally ornamented by sunk panels or by relief bands (Fig. 231) (Mauch, Arch. Ord. Pl. 62), the latter being commonly enclosed by cymas and pearl beads.

If the lower side of the archatrave appeared too broad, its centre was decorated by a moulded or ornamental band, and it was so divided in two halves (Fig. 232). When the architrave was composed of two beams placed side by side, the under edge of each could be decorated by a simple sunk or ornamental panel, or these moulded sinkings could be arranged symmetrically about the central joint (Fig. 233).

Wooden beams have been treated with exhaustive fullness in the consideration of the construction of ceilings, and it only remains to briefly mention trussed beams or girders, which play

an important part in bridge construction; whether of wood or iron, lattcie, suspension, or girders supported by piers, their nature consists in this, that the bearing upper and lower members are connected by stiffening members, and are so fastened together, that the girder becomes an inflexible whole like a roof truss. What was said of visible wooden and iron roof construction therefore applies to the construction of girders, but especially the frequently repeated general law, than in engineering construction on a large scale, the tectonic solution of the problem is to be sought in the plainest and clearest construction, and not in the paltry treatment of details. The recognition of the external appearance of a perfected construction, as being esthetically valuable, is more important than any attempt to conceal the construction by covering the structural forms by decorations in thisn metal or boards. In the course of the entire discussion, we have already spoken as occasion offered, of the general peculiarities that may come into consideration in the construction of bridges of iron or wood, so that scarcely anything new remains to be said of the treatment of the girders; they should be regarded as being resolved into their parts, which will then receive examination elsewhere in relation to principles and in connection with other things.

β. Entablature in connection with the classic orders.

Classic architecture based the proportions of the intercolumniations and their heights on the lower diameter of the columns, and fixed certain normal proportions that were more or less b binding. Such normal ratios can evidently possess but a limited value; for the distance in the clear between the upper ends of the columns, or rather the actual span of the architrave, chiefly depends on the resistance of its material to transverse stress. Easily fractured stone required the columns to be set closely, and on the contrary tough stone permitted them to be spaced widely. Since the classic columns had normal proportions of height to a certain degree, the Doric order could have relatively wide intercolumniations if low, but must have narrow o ones if with very tall columns; for if the extreme allowable span of a stone beam is fixed at about 20 ft., the height of the order would depend on this span only within certain limits, and the character of the entire order might change without al-

altering the actual span of the architrave.

Ionic and Corinthian orders as well as those with pedestals, always appear to have relatively narrow intercolumniations, since their height is great in proportion to the lower diameters of the columns. An old French edition of Vignola's Orders gives the following practical proportions, which may properly be taken as normal:-

Let D (Fig. 234) = lower diameter and H = height of the column; w, w', w'' = distances between their axes; H' = total height with architrave, frieze and cornice; then approximately;

	H	w	w'	w''	H'
Tuscan order,	7 D	1.5 D	3 D	4 D	9 D
Another examp.	7.5 D	1 2/3 D	3 1/3 D	4 1/2 D	9 1/3 D
Roman Doric	8 D	2 D	3 1/3 D	4 1/2 D	9 3/4 D
Roman Ionic	9 D	1 2/3 D	4 D	5 2/3 D	11 D
Roman Corinth.	9 1/2 D	2 D	4 D	5 1/2 D	11 1/2 D

These proportions only give starting points, correct only in a general way, so as not to approach too closely certain limits, which may not be exceeded in usual cases if good proportions of the orders are desired. If the architrave is to be supported by arches (Fig. 235) the spans may be greater; the work just mentioned gives the following normal proportions for this case.

	H	w	w'	H'	w''	w'''
Tuscan order	7 D	2 D	5 D	8 2/3 D	7 D	3 1/2 D
Another examp.	7 1/3D	1 3/4D	5 1/4 D	9 1/4 D	7 D	3 1/2 D
Roman Doric	8 D	1 3/4 D	5 2/3 D	10 D	8 D	4 D
Roman Ionic	9 D	1 3/4 D	6 D	11 D	7 1/2 D	4 1/2 D
Roman Corinth.	10 D	6 1/2 D	6 1/2 D	12 1/4D	6 1/2 D	4 1/2D

For orders with pedestals (Fig. 236), letting P = height of pedestal; H = height of column; H' = total height, other notation remaining as before, the same book gives the following n normal proportions for this case:-

	P	H	H'	w	w'	w''	w'''
Tusc. ord.	2 1/3D	7D	11 D	13/4D	61/2D	8 D	41/2 D
Anoth.ex.	21/2D	7.5 D	113/4D	1 3/4D	63/4 D	81/2 D	43/4 D
Rom.Doric	22/3 D	8 D	123/4D	2 1/2D	7 D	9 3/4 D	5 3/4 D
Rom.Ionic	3 D	91/3D	141/2D	1 1/2D	73/4D	91/3 D	6 D
Rom. Cor.	31/3D	10 D	151/3D	2 D	8 D	93/4 D	6 D.

γ. Arrangement of piers and architraves in girder bridges.

The piers of most girder bridges and of similar structures are usually strong wooden trestles or masses of masonry, or more rarely are iront structures, which serve as the abutments of the bridge girders. According to their arrangements they a are either end or intermediate piers· they consist of a base, the pier itself, and the cap or coping for receiving the bridge girder, according to whether they serve as piers of bridges leading across a river, or as those of viaducts or aqueducts.

Under all circumstances the base serves as a firm and broad foundation for the entire structure, and bridges over rivers or arms of the sea must be constructed with reference to the highest and lowest water levels, to high water as well as to the ebb and flow of tides, it serves as a wave and ice breaker,
[illegible]-
and as such has its peculiar form corresponding to the material purpose, and may be provided with a coping or crowning course, or be prepared to receive the body of the pier by means of any suitable transition form; the entire pier is diminished upward, partly to save material, partly to less obstruct the passage of water, and also in many cases to avoid loading the foundation too heavily, besides it always looks better than if it were not diminished. The transition from the base to the body of the p pier with its projections at both sides and ends, permits the most varied changes of section, that exert an essential influence on the pleasing form of the bridge pier. The architects of the middle ages fully understood how to effectively treat these projections, which served to beeak the force of the waves, sometimes erecting chapels on them, sometimes furnishing them with platforms or balconies, accessible only by means of steps, from which aid could be given to sailors or logs could be prevented from striking the pier.

The base of the pier and its projecting ends were not constructed with sole reference to a pleasing effect, but to break the waves, to admit of the use of the plainest rough and rock-faced ashlars, and the strongest mode of anchoring the stones by means of iron cramps; when such pier heads were protected by ironwork, they have a fine effect.

The body of the pier is lacking in many cases, the girder being placed directly on the substructure, which is then coowned

by battlements, by a tower, a pedestal supporting a statue or group of statues, a through pier serving to conceal the junction of the ends of two girders, the body of the pier sometimes rises from its base leaving a bold offset to serve as abutment for the struts of a wooden abutment bridge (Fig. 237).

The coping under the girder serves both as a block for its support and as a cap for the pier. For the first purpose, it should have a strong projection where it receives the girder; for the latter it must have a bold cornice Fig. 238), which may be profiled in various ways according to the character and arrangement of the bridge, whether it is to be in a city or in the country, connected with fortifications or be a simple viaduct or aqueduct, be in a park or in a narrow and rocky valley, in accordance with which it should make a more or less pleasing impression corresponding to the locality and its purpose, or be more or less robust or graceful.

The corbelling at the top of the pier, angle projections, t tower-like additions, towers and other moderately effective structural motives for developing the bridge pier architecturally,should be employed wherever possible in order to.make a real architectural work of the simplest and most economical problem of bridge construction.

Reference must once more be made to the general considerations on the problems of engineering, where anticipating this opportunity, we suggested an esthetic expedient for treating lattice bridges, the least pleasing of all bridges, so that their parts might be in harmony with each other,and the whole be suited to the surrounding landscape.

The abutments at the ends of the bridge might have a richer and more pleasing treatment by using known architectural motives, than is usually accorded to them. Generally they are merely terminating masses of masonry, which resist the pressure of earth like retaining walls, and whose external appearance is principally dependent on the choice of the kind of masonry. A special emphasis should be laid on a transition between the abutment and the girder so much the more, because the unpleasing junction of the girder and pier is generally neglected. Hence the so-called corbellings are valuable esthetic expedients, and the hardness of the junction of the horizontal and

vertical lines of the end of the bridge should be broken by f flights of stairs (Fig. 140), pendentive vaults in the angles with the shore walls (Fig. 241), angle towers (Fig. 242), buttresses and similar architectural motives. This hardness disappears in arched bridges, whether built of masonry or merely b bridge girders of curved form.

4. Arches above Piers and Columns.

α. General.

Fixed rules cannot be given foh the proportions of arcades without regard to their purpose, for which they are employed; the effect of the arch will be the more powerful, the greater its radius, and the smaller the height of its support (Fig. 243), it will appear to be heavily loaded and weak if the arch be too thin, lightly loaded and clumsy if it be tbo deep. (Figs. 244, 245). The form of the arch has for us something peculiarly characteristic through associated ideas, segmental and elliptical arches of low rise seem to be depressed (Fig. 246), and this characted of depression corresponds in the fullest degree to the arrangement, where the supports of the arch are low, as in low halls and bridges; it is more or less opposed to designs for rooms of considerable height and to spans on high supports; the depressed arch, whether segmental or elliptical, only looks well as a discharging arch, when the arch merely serves its p purpose without raising the question of making a pleasing appearance (Fig. 247). Its stability is increased and its appearance becomes more pleasing, if its depth be increased torard the abutments (Fig. 248). The elliptical arch of low rise is fully justified when constructed in a small span between abutments which serve as corbels (Fig. 249). The abutments may then be replaced by supports or corbels of different forms, which likewise support the elliptical arch (Fig. 250). In many cases the broken segmental arch may be used (Fig. 251), but it is s strictly only a pointed arch, in others the broken oval arch may have a very elegant effect, since it surpasses the segmental and elliptical arches in pleasigg effect, for example if its rise = 1/3 its span or 1/2 if its curvature be as regular as possible.

The semicircular arch always appears pleasing, if its lower ends are not concealed by a projecting impost cornice; it suits

any proportion between its span and the height of its supports; it may spring directly from a base, so that its piers are omitted, or it may be placed on very high supports without producing a disturbing effect, although a pointed arch is more pleasing in the last case, it may be strongly stilted if necessary; in brief it is better suited to all circumstances than is any other form of section.

The pointed arch is least adapted to the arrangement in which the vertical direction is to be specially accented. Various c structural methods of determining the radius of the pointed arch were known in the middle ages. 1, the radius = 2/3, 3/4, 4/5 = $\frac{n + 1}{n}$ × span (Fig. 252). 2, the radius = hypothenuse of a triangle with sides to each other as 1 : 1, 1 : 2, 1 : 3 = 1 : n. 3, the centres of the arch are found by projecting the angles of the polygon on a diagonal (Fig. 253). 4, the centres are found on a diagonal of the polygon, so that the pointed arch passes through two or three angles of the polygon (Fig. 254). All these methods of construction have a single purpose, that of aiding the enlargement of the pointed arch to full size and of obtaining exact work in stonecutting, some of them possessed peculiar advantages in the construction of forms of tracery, while others were pure trifles. It would be well in practice to determine the centres of the parts of the arch, both pointed or oval, by any fixed rulesso as to lessen the labor of drawing them full size. Compare the constructions (Fig. 254 a). All kinds of combined arch forms (Fig. 255) like those preferred in mediaeval and moslem architecture, in the Dutch Renaissance, and especially those composed of concave and convex curvatures, have not a structural but merely a decorative value, and should therefore be excluded from structural designs as much as possible, being relegated to the domain of decoration, where they are certainly justifiable. For example, small dors or windows, cellar openings, narrow openings in walls, which are covered by a single stone, also small canopies or the coverings of small niches in walls, may well be finished in arch forms combined in the most various ways, while the same forms would not be structural if used on a large scale, and should be avoided for that reason.

The segmental arch requires an increased depth toward the

abutments to increase its stability under a greater load; on the contrary the pointed arch requires this increase toward its crown (Fig. 256). To a knowledge of this fact we owe the feeling of quietude arising from an assurance of a correct mode of construction, in seeing one of these two cases; such quiet would scarcely be felt by one of the uninitiated, since the associations of ideas here considered would then be wanting to them. An arch of low rise can support a proportionally light load alone, but on the contrary a pointed arch can support a heavy one; therefore on an association of ideas is based the visible need for a flat arch to appear lightly loaded, and a pointed one heavily loaded at the centre, i.e., a large mass should be placed at its apex. Where attention is not paid to these considerations, unpleasing effects will be produced.

The same is generally true of the forms of section of arches, that was stated in relation to side arches; it only remains to be added, that the profile of the archivolt (Fig. 257) may change its character:- 1, according to the depth of the arch; 2, according to its projection from the face of the wall; 3, according to the desired inclination of the splay for admitting light, and which is tangent to the extreme projections of the profile.

β. Arched bridges.

We here apply this term in a general way to combinations of arches and piers in bridge design, whether gate bridges or openings in a wall permitting a road to pass through under a masonry bridge, bridges of masonry or girder bridges with curved girders of wood or iron.

Gateways include gateway bridges and will be considered in connection with openings in walls. Most that we have said of piers in connection with bridge construction is also true of arched bridges, so far as these are structures with girders.

As for arched bridges of stone, they require the imposts to be made strongly prominent by a horizontal incision and a clear treatment of the abutment.

In many cases the impost of the arch will at the same time be the coping of the pier, or if the pier be lacking and coincides with the substructure or base, the covering block itself forms the impost; in other cases the arch springs directly from

the foundation of the bridge, so that an impost cornice becomes unnecessary. For known reasons of stability the lower part of the arch should be built with horizontal courses to about half the rise of a semicircular arch, rather more for a semi-elliptical arch, and about one third for a pointed arch, i.e., a w wall mass gradually widening upward is formed by corbelling out the separate courses of stone, and the arch presses against this as an abutment. This abutment mass should differ from the arch itself in material and structure in many cases, and it m may be made especially prominent in others (Fig. 258). At the same time the principle of economy, which plays such an important part in engineering, will generally require that to characterize the abutment it must be dressed smooth, if the arch is built of rock faced ashlars, or that it be marked by enclosing members, coats of arms, emblems and other decorative expedients if the arches are dressed smooth on ornamental city bridges. The segmental arch always requires a skewback normal to its curve, and has a bad effect if it abuts directly against the cap of a support (Fig. 259); if the arch is not bordered by moulded members it does not appear more ugly, than if these borders are composed of horizontal headers or abut against each other, unless the intersection is especially supported by a c corbel. The first radial joint of the segmental arch separating if from the skewback, which is wrought from a single block or from horizontal courses, may be marked by a boldly profiled inserted slab, the skewback itself may be formed as a corbel in small bridges (Fig. 260).

If the separate bridge arches spring from skewbacks quite far apart, or the piers are of unequal width, a small arch may be inserted between the ends of the main arches to save material; this especially occurs in the bridge Quattro Capi at Rome, whose middle pier is built on a small island in the Tiber; the end piers may also be broken by gateways in many cases, or outlet openings may be left above the abutments to remove the water from the bridge way.

In the different possible arrangements many motives capable of execution are given, which admit of the most varied structural or picturesque designs in connection with offsets of piers, projecting caps, stairways, towers or bridge chapels, custom

houses, portals and similar accessories. The angle corbellings, pendentive vaults, corbellings, buttresses, monuments and groups of figures, in brief whatever aids in the enrichment of bridge construction is entirely permissible.

If girders of wood or iron having the forms of arches are combined with masonry piers, these should have proper abutments for the girders, and these should generally be skewbacks, conindiding with the radius of the arch at the joint.

γ. Covered bridges and those built upon.

If the bradge way is covered by a roof, the structural ideas result from the arrangement of the supports, which bear it, a and from the arrangement of the bridge piers on which it rests; not to load the bridge too heavily, the construction of the r roof should be as light as possible, and the spans between the supports as great as possible; these rules vanish at the piers themselves, when a grouped arrangement of columns is desired.

From this ground idea results the anrangement of closed pavilions, towers and portals on the end and intermediate piers of the bridge, and of open halls over the bridge way; but such arrangements are carried out in the most varied ways in the few existing examples.

5. Buttresses and Flying Buttresses.

Buttresses are either added thicknesses given to walls to prevent their yielding, or to resist the thrust of vaults; their nature is identical in both cases, since a wall can only yield sidewise in consequence of a force acting in that direction, either at a right or some other angle with the wall; it is immaterial whether this force is caused by a vault or not.

The buttress (Fig. 261) must always be arranged in the same direction as the force, whether this be perpendicular or oblique to the wall; if two or more forces act on the wall, as many buttresses must be arranged, one opposed to each force, or since the forces may be combined in a single resultant of determinate magnitude and direction, a single force may oppose its direction, with a force having the magnitude of the resultant. The force acting against a wall may be distributed over its entire surface, as in case of pressure of earth, or it may act at one or more points, in the first case it would tend to slide the entire wall sidewise; in the second it tends to overthrow

the wall or cause it to bulge.

If two or more forces acta against a wall, the construction of a buttress simply consists in connecting the points of application of the forces by a rigid body, they applying to this body a force havin. the same line of action and magnitude as the resultant of the forces, which it holds in equilibrium.

The force F (Fig. 2.2) sufficient to move the wall sidewise is proportional to the weight P of the wall, i.e., to the pressure it exerts on its foundation and to the coefficient of friction f of the materials of the wall and foundation on each other; thus $F == P \times f; P = \frac{F}{f}; f = \frac{F}{P}$, the area and form of the bearing surface not being considered. The more firm, solid and heavy is the masonry, the less is sliding of the wall to be f feared.

As for the overthrow of the wall by the force k sufficient to do this, which is proportional to the weight gacting at the centre of gravity of the wall, to the distance x of the horizontal distance projection of the centre of gravity from the point of rotation C, and inversely proportional to the perpendicular a let fall from the point C on the line of action of the force k; or expressed in a formula, $k = \frac{g\ x}{a}$, since from the equation of the lever, $a = g \times x$.

The formulas also shows that when the force is given, which tends to overthrow the wall, that will be more stable, the greater its weight, its thickness, and the lower the point of application of the force, or the steeper the line of action of the force, and k becomes entirely undetrimental when $C \times x$ is a maximum, or the weight or thickness of the wall = infinity, or the point of application coincides with the point of rotation.

Evidently the weight C and distance a being constant, x may be increased to have the centre of gravity fall as near its inner side as possible; this occurs if its height be increased and if it is battering externally. For example, if a wall with thickness b and height 3 b is built in three thicknesses, the proportions of the dimensions of the first being b : b, of the second $2b : \frac{b}{4}$, and of the third $4b : \frac{b}{2}$, its weight and volume would be unchanged, but = 1/2 b in the first case, in the last = 21/32 = 2/3 b in round numbers. Thus the wall becomes more stable by externally having a batter or having offsets, according

to a fixed law. When x = b it reaches its maximum; but this w would occur when the wall is corbelled out so much on the inside, that its mass is bisected by the vertical axis A.

A buttress is nothing more than a wall mass, safe against being overthrown by its conditions of stability; its effectiveness thus increases with: 1, its projection at its base; 2, its load, i.e., with the use of heavy building stone and its increase in height; 3, by corbelling it out on the inside.The point of application and line of action of the force k are almost always given; if the buttress is arranged to resist the thrust of a vault, the point of application of the force k is found at the intersection of the tangent to the central line of pressure with a vertical through the centre of gravity (Fig. 266); the tangent K is itself the line of pressure at this point. The weight C of the wall and the buttress combines with the thrust at the point of application, forming a resultant, which must lie entirely within the buttress.

Thus the problem is as follows, if the stability of the buttress and wall is to be increased with economy of material; 1, the point of application of the force must be kept low; 2, the line of action of the force must be steeply inclined; 3, the projection of the base of the buttress is to be kept small.

The first requirement will be satisfied by making the springing point of the vault as low as possible, the second corresponds to giving the abutment as great weight as possible and to corbelling the construction out toward the interior, so as to incline the axis of the masonry inward, that is drawn through its centre of gravity; the third condition corresponds to the projection of a part of the buttress on the interior, to a reduction of its mass, when permitted by the course of the line of pressure (Fig. 267). Hence openings are admissible at the base of the buttress as well as above a line of pressure. It follows from what has been said, that the buttress should have a projection greater than its breadth, since its stability increases more with an inceased projection, a heavier load and by corbelling out inside, than by an increased breadth.

According to all this, the esthetic ground ideas relating to the formation of the buttress are as follows; the buttress requires a considerable projection at its base; as a wall pilaster,

which is to be regarded as an addition at right angles to the wall for strengthening it, the thickness of the buttress must at least equal that of the wall, or it will appear too weak. Openings for doorways are admissible in its lower portion, the base of the building must be broken around it. The offsets in breadth or thickness should be covered by simple inclined planes, larger or smaller in accordance with the arrangement of the whole, and which may be covered shed or gable inclined roof stones to shed the rain water (Fig. 267). If this inclined surface be of considerable extent, it may properly terminate in a gutter with a lower opening for discharge of the water, the l last affording opportunity for decorative ornament. In case of strongly projecting buttresses, not only a string course at t the lower ends of the windows, but also a gallery, will be desirable sometimes, and this forms a passage around the building that requires openings through the buttresses, or to be broken around them (Fig. 268).

The separate offsets of the buttress may be treated as free ending masses, and may receive light decorative ornaments. The leading ideas relative to the top of the buttress are as follows:- It is either terminated beneath the main cornice in an inclined plane or a free ending piece of ornamental work; or it is connected with the main cornice, of which the whole or merely its upper or lower members may be broken around the buttress (Fig. 269); or lastly it interrupts the main cornice, w which dies against either side of the buttress (Fig. 269); in the last case it may be terminated by heavy masses to which t two ground ideas are applicable. This load either consists of a figure decoration, or the pinnacle takes the form of a stone pier diminishing in pyramidal form, or that of a stone pier similarly diminished; the motive of groups of figures is preferably that of the Renaissance, and that of a pyramidal mass of stone belongs to the Cothic; in place of the latter obelisks and employed in the late Renaissance after the precedent of the tomb in Albano.

The most effective means of loading the upper end of the buttress always consists in corbelling out the main cornice above arches, which throw on the buttress the entire weight of the mass between two buttresses (Fig. 270); a still heavier loading is attained by means of a kind of attic story erected above

the main cornice and constructed of simple arches spanning the space between two buttresses (Fig. 271). The arches could be utilized as openings for admitting light to the attic of the building, being at the same time windows in a small corridor or in small chambers in the roof. The Gothic style indeed introduced the so-called gable dormers for this purpose to load the buttress in accordance with a similar principel.

If the buttresses are arranged inside a building, it may well happen that they need to appear externally, only as low buttresses of moderate projection (Fig. 272); these may terminate at top in any suitable manner without the necessity of vertically dividing the upper wall of a building in several stories; in other cases they may perhaps require a very wide projection, according to the arrangement of the vault, so that by vaulting over the spaces between buttresses may be formed external galleries over deep recesses, or above a row of internal chapels. (Fig. 273).

As the breadth of the buttress is diminished by offsets, there may be offsets in the thickness also, but which can only be small on account of the small thickness of the buttress; (Fig. 274); it is otherwise if perhaps bridge piers have buttresslike offsets, when the breadth of the pier is considerable, on angle buttresses of towers that are always developed on a broader base, or on additions for strengthening the angles of the bases of monuments, fountains, etc.

Groups of buttresses are always required at the angles of v vaulted rooms and buildings, especially on towers, and they are sometimes employed in connection with stairway towers. The usual modes of arrangement are the following (Fig. 276); the buttress is set back from the angle at a, directly at the angle at b, or diagonally at c; the corresponding arrangements of a stairway tower would be as a a′, b′ and c′, this tower being one of the most appropriate expedients for strengthening the angle, at the same time playing an important part as a servants' stairway in many cases. The group of buttresses may combine in in a mass at their base, separating above this (Fig. 277); by the use of diagonal members may be obtained peculiar arrangements of piers, as in the treatment of buttresses in Gothic style, memorial columns and similar forms of piers.

Buttresses are in nowise a monopoly of the Cothic style, so as to be suited to that alone, or that they must always be treated with Cothic forms; then are a general result of vaulted construction, and in case of a problem similar to those solved in the middle ages, we cannot dispense with this expedient of the buttress. But if we desire to give to it a Renaissance form, thus entirely neglecting the existence of the Gothic style, we should return to the forms devised by the middle ages up to a certain degree; the generally valid part of mediaeval architecture is this, that it created forms which cannot be replaced by better ones. To exclude those forms on principle, would be to advance backward. Conversely we must never feel constrained to retain the detail forms of Cothic employed in its buttresses and flying buttresses, because it knew not how to use others. On principle we should avoid the use of buttresses as merely decorative parts, as likewise occurred in the Cothic style nothing is to be resisted, but certainly must not fall into the opposite error of the Renaissance, of greatly enlarging the volutes of modillions intended for a small scale, and of employing them as purposeless forms for buttresses, in the sense of being general form symbols for the indication of a horizontal thrust.

Flying buttresses are counter arches, which do not transmit the thrust of vaults to the mass of a buttress by a heavy and inflexible buttress pier, but by an arch, which itself exercises a thrust. Flying buttresses become necessary in all basilican designs of several aisles, they may also be used when the buttresses are entirely omitted, but fixed points exist, for example rocks, massive walls, etc., to which the thrust of a vault may be transmitted. Finally they lose their function as arches exerting thrusts if free standing piers or the angle masses of towers, are connected with the principal mass of a building by oblique struts or by horizontal bridges supported by them.

The following modes of arrangement are possible;-

a, three or four aisled basilican buildings.

1, merely a single buttress is required; 2, two separate buttresses are necessary (Fig. 278). 3, to increase the resistance are necessary two flying buttresses, connected together;(Fig.279)

4, for the same reasons but one flying buttress is required, though this must be very heavily loaded.

b, five or six aisled basilican buildings.

1, the pairs of side aisles are of different heights. Two flying buttresses are then arranged above each side aisle, as on the cathedral at Beauvais (Fig. 280), or a single flying buttress spans the outer aisle, while a second larger one is thrown over both side aisles to the centre aisle, as on the cathedral of Notre Dame at Paris (Fig. 281). m, the side aisles are of equal height, when the inner aisle requires two, and the outer aisle a single flying buttress (Fig. 282).

The buttress mass against which the flying buttress abut must satisfy the requirements stated at the beginning of this Chapter, but it is particularly necessary to locate its centre of gravity nearest its inner side by corbelling inward the masses.

The flying buttresses are themselves to be regarded as arches, and are to be correspondingly treated, they will be more stable if in the form of half a pointed arch, than that of a quadrant; further in case of very high centre aisles like those of the larger Gothic cathedrals, they not only resist the thrust of the vaults, but also hinder the vibrations of the centre aisle caused by violent storms. In such mighty structures it may happen that the total mass of the buttresses and the flying buttresses presents so large a surface to the action of the wind, that they require to be connected by transverse arches. Should such a case actually occur, the building would be concealed by a formal structure of buttersses and arches.

If the wall mass of the buttress is to be decorated, one must distinguish between those points that may be made lighter by openings without injury to their structural meaning, and those points which may be merely decorated by niches containing figures, canopies, inlaid panels, etc. To utilize the upper edges of the flying buttress as channels for rain water, which was done in the Gothic period, will seldom be repeated, being not a very practical procedure.

It is self evident that a buttress can fulfil its purpose of strengthening the wall only when the masonry is well bonded t together; hence a buttress could scarcely be constructed of boulders or Cyclopean masonry. A good bond can only be obtained

with rubble of quarried stone, ashlar masonry or brickwork; the bonding of ashlar masonry would be strongest if blocks cut with reentrant angles were used (Fig. 283 a). If a wall is about 3 ft. thick with ashlars about 2 ft. long and 1 ft. wide, a buttress projecting 3 ft. and having an equal width would be well bonded as shown in Fig. 283 b. If the buttresses are built of brick masonry all offsets diminishing upward must diminish by courses.

D. OPENINGS IN WALLS.

Openings in walls are; I, openings in masonry; II, openings in walls of wood or iron. Their purpose is either the admission of light when they are windows, or to permit passage when they are doors and gateways. To the latter may be added the p portals of tunnels, gateway bridges, openings for passage of water, etc. The leading idea in the formation of openings in walls results from the construction of the wall, a part of which is removed by the opening, so that the bonding is interrupted in one place, the adjustment of the interruption of the bond depends first on the clear width of the opening. The formation of the opening is further arranged in accordance with the thickness of the wall, and with the quantity of light to be admitted to the room, or in case of doors to the desired ease of passage.

The formation of openings in walls further depends on the means of closing them, and finally on the two points mentioned in Tectonics, the self limitation of the material next an opening in the form of raised members and borders, as taking the form of a withdrawal of the material from the opening and laying bare its interior.

I. Openings in masonry walls.

We shall now examine first a few problems, such as commonly occur in case of openings in walls, before considering the details of doors and windows.

a. General.

1. Spans of openings in walls and their bond.

The simplest mode of covering narrow openings in walls of masonry will be by a single lintel; this may be cut in various ways (Fig. 284); but it would thereby be weakened, and a fracture at its middle is to be feared. The fracture of a simple

lintel will less easily occur when wrought from a very hard m material, or if made deeper at its centre (Figs. 284, 285; a stone hollowed out on the underside will not be as easily broken if it is formed like a keystone (Fig. 285), or if a joint be made at that point where it threatens to break. Whether hollowed or not, a stone may be protected from fracture by its load being supported otherwise, most simply by two blocks (Fig. 285). This may be most perfectly done by three voussoirs (Fig. 286) which act as an arch. The same end may be attained in many cases by allowing a keystone to extend through two courses (Fig. 286). Further, three voussoirs may be so jointed that their l lower surfaces form a plane. These and other modes of covering narrow openings are especially used for cellar windows, the a arched form of the covering stones may in most cases be chosen at pleasure, and it permits the most diverse forms (Fig. 287), since it is scarcely necessary to consider merely the decorative side of the arrangement.

As for what concerns the bond of these simpler constructions of openings in walls, the following motives would result from the previously treated ground laws relating to bonds, it being assumed that the construction of the covering and jambs is to be in cut stone.

1. In masonry of boulders and rubble, the stones may have i irregular and inclined joints, since these kinds of masonry a are better adapted to random joints than to vertical ones.

2. In polygonal and Cyclopean masonry, one must seek to obtain a suitable lintel with a horizontal underside, or to arraange three stones with radial joints (Fig. 289); further, to arrange the stones of the jambs to form regular jambs, whether vertical in rectangular, or inclined in trapezoidal openings.

An interesting example of a small window with a bond suited to Cyclopean masonry is here given from the eastern choir of the cathedral of Treves (Fig. 290), belonging to the end of the 12 th century.

3. In irregular masonry mostly composed of blocks with reentrant angles, an example of which was given in Fig. 7 and found in Greece, the most varied modes of spanning the openings became possible, the joints and possible projecting bosses giving rise to peculiar forms. Such arrangements are entireln pleasing

and proper for the fortress character of many buildings, if not affected as in the windows of the new palace in Baden-Baden. (Fig. 291).

4. In mixed masonry partly built of quarried stone and partly of bricks or stones from river beds in herringbone bond, t as a rule the openings should be covered by lintels, against which the bond dies; or by arches against whose top the bond stops as it may chance. Beautiful examples of such mixed masonry of the Roman period and of the middle ages are shown in the illustrations from the imperial palace in Treves and from a b buttress of the Nicolai church in Bautzen (Figs. 292, 293, 294). In the first example the masonry below the springing consists of alternations of three courses of bricks with three of quarried rubble; the bricks of the arches are not trapezoidal but are merely thin bricks, and the stones are regularly dressed but not as ashlars. The bricks are 13 3/8 ins. long, 1 9/16 ins. thick, and the beds and joints have the same thickness as the bricks. The largest tile in the arch measures 21 5/8 ins. square by 2 3/4 ins. thick. The dressed stones are 5 1/2 ins. thicg and 7 1/8 to 8 11/16 ins. broad. Tn the last case (Fig. 294), larger blocks of granite alternate as voussoirs with smaller fragments of granite, and the masonry consists of entirely irregular granite rubble, the angles being strengthened by larger regularly dressed blocks of granite.

Opus reticulatum is seldom employed otherwise than in combination with regular arches of bricks or stone, against which abuts as may chance.

5. In peculiar kinds of ashlar masonry like that previously described, from a church in Naples and the fortress in Florence, simple narrow openings were formed, covered by a single voussoir.

6. We have already considered generally openings in ashlar masonry for small spans, as in cellar windows and openings of all kinds for admission of light. In case of wider openings, there is to be especially examined their covering by arches, (segmental, elliptical, semicicular and pointed), as well as the jointing of these arches in connection with the bond of the masonry.

To not weaken the crown of the arch, the extrados is either drawn parallel to the intrados, or the voussoirs are arranged

in accordance with the coursed bond, that the keystone may have the required height. If the arch consists of onle 3, 5 or 7 stones, it will not be very difficult to bond them with the ashlar masonry, since the arch will scarcely affect more than four courses in height. for practical reasons the divisions of the arch must be so chosen as to be suited to the natural height of the courses of stone, being at most 15 3/4 to 23 5/8 ins. thick; for reasons of stability it is preferable to compose t the arch of as many voussoirs as possible. Therefore it would be well to base the division of the arch on the least thickness of layer of the stone, since the voussoir must be wider at the extrados than on the intrados, and to divide the intrados in as many stones as the space permits, since for reasons of stability is is best to lessen the span of the arch by corbelling at the abutment, and this division may vary within tolerably distant limits.

The division of the arch into voussoirs and of the wall in courses will collide, if either division be not dependent on the other. In regard to the division of courses and voussoirs, the following cases are possible.

a, the courses are of equal height; b, heights of courses a are alternately equal; c, the courses have unequal heights; d, voussoirs are of equal width; e, widths of voussoirs are alternately equal; f, their widths are unequal.

Since the construction depends entirely on the form and span of the arch over the opening, each separate case will lead to a special mode of division; it is sufficient to remember here, that strongly loaded segmental arches should have their depths increased toward the abutments (Fig. 295 a); arches with high rise, toward their crowns (Fig. 295 b); at the same time when the widths of voussoirs are unequal, they should be wider toward the crown than the abutments.

The jointing of arches of wide span or the covering of narrow openings is always to be arranged according to the heights of the courses of the material when the wall is of brick; if the arch itself is of brick it should always be constructed of voussoirs or bricks of tapered form, or the bricks man be rectangular and the mortar joints be wedge shaped. But in all cases it will be bes to make the extrados of a bricg arch parallel to the intrados, for it is always preferable in brick constructi

to employ a normal form of brick throughout; wedge-shaped mortar joints are preferable to tapered bricks, and to dress off the outer ends of the bricks to unite well with the wall bond would not only be formal but useless.

If it is desired to make a brick arch not concentric but with a stepped extrados as in ashlar masonry (Fig. 296), this can be done in two ways, either by horizontal and vertical or horizontal and radial limiting joints. but this arrangement w would possess no considerable structural value, particularly in the second case, since the bricks would have to be cut and rubbed to taper shapes, but would be justified in many cases for decorative reasons; further one would scarcely increase the depth of a pointed brick toward its crown, or of a segmental brick arch toward its ends (Fig. 297 a) for small spans, since cutting the bricks would make the strength of the arch doubtful, and to offset the bricks would make the arch appear ugly. To construct the arch of several concentric rings is structurally purposeless, since only a strengthened arch with radial joints extending through its entire depth would not only appear but would really act as such. Roman arches composed of several rows of bricks owe their strength only to the excellent mortar and not to their construction.

8. The arch may be decorated first by the alternation of the materials employed as in brick masonry, voussoirs may be inserted between the bricks of the arch. A second motive for decorating the arch consists in accenting its principal points, such as the crown, springing points, and the joints of rupture (Fig. 297 b). the brick construction of the Dutch Renaissance is characterized in this wau, where keystones, imposts and stones at joints of rupture, were placed in arches of the most different kinds, while the remainder of the arch was entirely of brick.

Not only the Dutch but also the Italian Renaissance sought to relieve arched construction by accenting the springing points, points of rupture and crowns, especially in the doorways of the simpler houses and also in simple plastered ceilings , whose plainness required the invention of original motives. A few examples of such motives for doors of houses from Como, Bergamo, Bellagio and Brescia, might find place here (Figs. 298, 299, 300); the latter is more characteristic than beautiful or worthy of imitation; all the joints of the splayed soffit and jambs

radiate from a single point at the height of the human eye. But with the exception of those marked f, these joints are not real but sham ones. The idea of this sham architecture cannot be regarded otherwise than objectionable.

An esthetic motive suitable for ordinary plastered masonry consists in covering the real arch over door or window openings by a slab of stone placed before it, which may have a moulded edge or be decorated by foliage, the key stone and imposts, as well as those at the rupture joints may each be treated in its own way.

The impost is always accented and its treatment may follow the most diverse modes; foliage, heads, shields of arms, etc., are suitable for its character. The keystone being the most i important point of an arched construction requires a special accent, in many cases it also serves the most diverse purposes, and may therefore sometimes be formed as a corbel to support a projecting cornice, sometimes be intented to support a bust, shield of arms or one bearing the number of the building. The noblest decoration of a keystone will always be a human head; symbolic emblems, heads of animals, etc., may be substituted for a head, according to the purpose and importance of the buildi

2. Thickness of wall and light and spacial character of doors and windows.

Openings in external walls in most cases are intended for admission of light to a room, or to give access to men or animals. Even embrasures, whose direct purpose is to permit the passage of a projectile, are always to be regarded as openings for light, since they must be so arranged for the object to be seen at which the projectile is aimed. In arranging plans of openings in walls, the leading idea for windows is admission of light; for doors to facilitate access; hence the opening should be widened either outside or inside; an external widening is necessary or suitable for doors used by large numbers of persons, and for windows not to be looked through outward, as in case of high church windows; an internal widening is desirable for many doors, when a room is to be quickly emptied of people, as for theatre and church doors; also for windows intended for looking through, like those of dwellings and many public buildings.

Another reason for deciding whether an opening in a wall shall be enlarged outside or inside is the mode in which the b doors or sashes are to open: if these are not folding the opening must often be splayed inside so that the door or sash does not project beyond the jamb (Fig. 301); if folding, the splayed jamb may be narrower and the opening may be splayed outside. If the door or sash is required to entirely fit into the jamb, pilasters projecting inside will sometimes be needed (Fig. 302), whose projection from the inner surface of the wall may be considerable, if the wall is not sufficiently thick to receive t the entire door or sash, that it may not project inside.

Conversely in case of doors, the doorway may project from t the outside of the wall, both to facilitate passage and to afford a projecting shelter, thus makind the opening in the wall deeper than could be obtained wit the thickness of the wall alone. This arrangement may be necessary for entrances of churches, palaces, city halls and similar buildings for public assemblies.

3. Means of closing doors and windows.

For all openings in walls intended to be temporarily open or closed, this requirement will aid in determining their arrangement in plan. Rectangular doors and windows are always preferable for rooms of dwellings on account of admission of light, the joinery, ease of opening and closing, and for placing curtains before the opening, that is usually spanned by a segmental or round arch. In public buildings, which require larger doors and windows on account of the depth of rooms to be lighted and the greater number of persons, the doors and windows need to be round headed, or the windows may be divided by mullions if quite wide; windows seldom opened by special mechanism for ventilation like those of churches and buildings for ordinary purposes of all kinds, depend less on the form of spanning the opening. It is generally unnecessary and bad to made the doors pointed at top (Fig. 304), even in case the form of arch prevailing in the building is pointed; this is one of the most common faults of architects ignorant of the spirit of Gothic, believing it necessary to make the doors pointed because of the windows.

The Gothic style indeed made doors pointed but seldom, the relieving arch was usually pointed, but the door terminated

by a straight lintel or this is cut segmental; but if the door is made pointed (Fig. 304) the internal opening must commonly have a segmental arch, since the door could not be opened if a pointed arch were used with a pointed tunnel vault above.

4. Limiting forms of the material towards openings as projections, borders and splays, its interior exposed.

We have already pursued the thought in various places, that ideas associated with convex and concave forms give the leading points for a multitude of esthetic forms. They play a chief p part in the architraves of openings in walls. Therefore the construction of these openings determine the choice of the sections of their architraves.

Let a b (Fig. 305) be the direction of a ray of light passing through an opening enlarged outside, and let c be a parallel ashlar of the wall; it is evident that the entire enlargement of the opening may be so moulded, that the splay a b forms the limit within which lies the moulding. Further, the entire space from c to d (Fig. 305 b) may be replaced by a border profile to make the architrave still wider; finally the parallel ashlars and their margins may be moved forward to the point e (Fig. 305 c), leaving the splay c d as in the first case, or this may be replaced by a moulding; in the two first cases the total width c d of the profile is greater than in the third case, t the enlargement of the opening is equal in the first and last cases, but the widths of the profiles are different. According to this principle of forming the openings, the free choice is open to us, of how wide to mae the architrave, and how much to splay the opening. The principle of this kind of architrave is based on the assumption that the opening in the wall is formed by omission, when the same bond is employed for the entire wall, whether of stone or brick; or in other kinds of masonry the o opening is enclosed by a layer of ashlars or bricks (Fig. 306). The second structural principle determines the choice of moulding for an opening consists in enclosing the opening by a special architrave, against which dies the masonry (Fig. 307).The masonry may be ashlar, Cyclopean, rubble, brick or any other kind, while the architrave is of stone or brick.

If we recall that by wall face we always understand the real or ideal vertical plane from which project the paneled ashlars,

and which coincides with the faces of those having triangular joints, in accordance with the first principle of the construction of openings in walls, the profile of the architrave is always behind the wall face, but it may project in front of that in accordance with the second principle; but principles must always be separated and never combined, so as to have the architrave project from the face of the wall, unless it is structurally separate from the wall, for otherwise surplus stone must be cut from each block of the architrave.

In very thick walls, the openings have very wide jambs, which may be constructed of ashlars in two ways, either as shown in plan at a and b (Fig. 308), where the splay is produced by stones set obliquely, or according to the plan c and d (Fig. 309), where the splays are replaced by rectangular offsets; the examples b and d represent the architrave as projecting considerably from the wall face. In case d the rectangular offsets may be replaced by small columns in windows and entrances, or the angles between the offsets may be filled by small columns (Fig-310), whose capitals support arches prifiled in any manner.

b. Special on doors, windows, gateways, etc.

As already stated, openings in walls are for admission of light as windows, or are passages of all kinds, doors, gateways, portals of tunnels, gateway bridges, for water, and others such as embrasures, for ventilation, etc. Windows are formed in vertical walls, either with a vertical axis like wheel windows, in which we include all windows arranged about a centre, or are skylights in ceilings. According to their uses they principally belong to dwellings, public buildingr and palaces, lastly to churches. We shall now describe openings in walls in the f following order.

1, windows of dwellings; 2, those of public buildings and p palaces; 3, those of churches; 4, wheel windows; 5, tracery of windows; 6, skylights. We distinguish the smaller entrances of private and public buildings as:- 7, doors; 8, larger gateways including city and fortress gates and triumphal arches; 10, portals of tunnels; 11, gateway bridges; 12, openings for discharge of water, for ventilation, embrasures, etc.

1. Windows of houses.

We first consider the windows of dwellings for the reason t that the most important separate motives may be derived from

these as being normal arrangements.

Windows of very plain buildings and of those merely intended for useful purposes will assume the simpler forms, already treated in the preceding pages. In this case the problem always is to obtain the best effect with the simplest means.

α. Cellar windows.

Little in general may be said here of windows in cellars of houses, sometimes introduced in dwellings, since the proportions of their forms change in each case. On account of their small height they are made as wide as possible to admit a considerable amount of light, and are then grouped by twos, threes, etc., splayed inside and spanned by a relatively low lintel, that may be omitted when the plinth itself forms the lintel ((Fig. 311). The profile of the architrave may be entirely omitted or be simply treated, shaped to admit as much light as possible, with an external rebate if wooden sash are necessary or if the windows are fixed, with an internal rebate that may be omitted, if the wooden frame fits into a rebate in the stone. (Fig. 312).

If the cellar windows only serve to light the rooms in the cellar, they are generally made subordinate, but the most varied combinations with the ashlar masonry of the substructure are possible, like those mentioned in the Chapter on the simpler methods of covering small openings in walls. Peculiar arrangements result from the combination of basement and cellar windows as will be lound later.

β. Windows in basement story.

Forms of windows in basement of lower story are always adapted to their arrangement

The basement of a house for rental will contain smaller and therefore less respectable dwellings, than that of the first story, since the doorway and entraice hall occupy a part of its space, or it may be taken for a small shop.

In detached houses and villas, the basement usually contains the reception room, dining room, etc., thereby becoming the p principal story, while the upper story becomes subordinate and contains the bedrooms, breakfast room, nursery, boudoir, etc.; if a second or third story is found in city houses for rental, these stories likewise contain subordinate dwellings. The character of the stories must be indicated in the architecture,

but at the same timee in the hegher houses the basement story forms the base of the entire building, and the upper story is its termination, and since it expresses the natural feeling, or more correctly speaking, accords with the ideas associtated with Above and Below, that the upper part should be light and the lower story heavier, a change must be made in the windows of the different stories, both in dimensions and in treatment.

If in general we name the story containing the best dwelling the belle etage, which may also be the basement in villas but will always be the first story in houses for rental, the following normal proportions , common in different places and based on the local units of measure, may serve as bases, and it is to be noted in this connection, that the greater part of the architecture of Dresden houses is based on a very careful consideration of practical requirements as well as the most pleasing proportions.

For an ordinary lower class for rental at Dresden.

Basement.	1 st or belle etage story.	2 nd story.	3 rd. story.
Shops.	3.94 × 7.55 ft.high.	3.77 × 7.06	3.77 × 7.06

The proportions in the above stories are:-

1 & 1.917	1 : 1.87	1 :1.87

For a better house for rental:-

3.94 × 7.55	4.26 × 8.20	3.94 × 7.06	3.77 × 6.89

These proportions in the different stories are:-

1 : 1.917	1 : 9.23	1 : 1.875	1 : 1.826

For a larger and better house for rental:-

3.94 × 7.55	4.10 × 8.36	4.27 × 7.87	3.77 × 6.72

These proportions are:-

1 : 1.917	1 : 1.888	1 : 1.846	1 : 1.782

The following apply to two story villas:-

Cround or belle etage.	First story.
4.27 × 8.20	3.77 × 7.05
4.75 × 8.52	3.77 × 6.72
4.43 × 8.37	

Stuttgart.

Basement.	First story.	2 nd story.	3 rd story.
3.28 × 5.58	3.44 × 6.89	3.28 × 6.06	2.95 × 5.40

Vienna.

3.94 × 6.89	3.94 × 7.58	3.94 × 7.54	3.94 × 6.56

Carlsruhe.

3.44 × 6.89 3.77 × 7.38 3.61 × 6.72

Berlin (according to Schinkel).

For a house for rental:-

4.60 × 8.20 4.60 × 9.20 4.60 × 8.20

For a villa:-

4.60 × 10.18 5.10 × 10.18

A few smaller Italian Renaissance palaces are given for comparison.

Florence, Palace Larderel.

4.60 × 9.50 4.60 × 9.50 4.60 × 9.50

Siena, Dwelling.

3.94 × 7.82 3.61 × 6.82 3.61 × 5.57

Rome, Palace Massimi (Peruzzi).

3.87 × 7.22 4.92 × 9.20 Mezzanine.

Rome, Palace A. Massimi.

4.40 × 8.03 4.43 × 8.75 4.00 × 6.23

Rome, Palace Firenze (Vignola).

4.04 × 8.00 5.80 × 7.85 3.64 × 6.94

While the architects of the Dresden school have pretty strictly adhered to the proportions of the windows of houses here given, the dimensions given for Stuttgart, Vienna, Carlsruhe and Berlin are merely approximate, but are not the normal dimensions employed in those cities.

γ. Architraves of windows.

Architraves, like the usual moulded portions, are wrought f from the usual stair step blocks in many places, where rendered possible by a great development of the quarrying of stone as in Dresden; the rough blocks have normal dimensions of 7.48 to 7.88 ins. wide, and the profile of the architrave varies from 6.02 to 6.96 ins in width; yet the same width of architrave is retained in the different stories, but this width may be increased from the least to the greatest measure, according to the richness of the profile and of the building, also according to the fineness or plainness of its character.

Since the clear width of the windows of different stories v vary according to the rules of the Dresden school, but the widthis of their archives remain constant with a normal width of 6.5 ins., the proportion of this to the clear width of the window varies between 1 : 7 and 1 : 9; hence the architraves of

of the narrow windows appear broad, while those of wider ones seem narrow. The Dresden dimensions are in general to be termed samll, owing to the fine grained sandstone used there; the architraves of classic and Renaissance windows are generally wider, being 1/4 to 1/6 the clear width of window.

We have so far considered the window and its architrave as it appears as a normal on houses having smoothly plastered or stone walls, where the architrave is not produced by splaying the angles of the opening, but by the separate lintel and jambs of the window. The projection of the jamb stones in front of the face of the wall must at least be 0.9 in. for plane ir 1.38 in. for moulded jambs to make its effect satisfactory; t the other practical dimensions are given in Fig. 313.

This Dresden school has fixed the following normal profiles for architraves of windows for the most varied cases occurring in practice, all having a strictly Renaissance character and being suited to the Pirna sandstone used, but which still leave the proportions of details to the esthetic sense.

1. For smaller windows (Fig. 314) of simple character, 6 ins. wide and 0.904 in. projection.

2. For smaller windows of richer character, 6 in. wide and 0.904 in. projection (Fig. 315); the sunk panels may have angles filled with rosettes, and in very rich arrangements, they may be filled by delicate ornaments.

3 to 8. For windows of average size (Fig. 316), simpler and richer, finely or more plainly profiled, 6.5 ins. wide, 1.38 ins. projection.

9 to 20. For broad windows (Fig. 317), more or less simple or rich, richly or plainly profiled, with or without sunk panels, 6.97 ins. wide, projection 1.38 to 1.97 ins.(Fig 317).

In all these profiles the ease of execution, general effect, the projections of each fillet, cove, round, reverse ogee, are considered in the most careful way. The peculiarities found in these profiles are the following.

No. 1 has least projection; nos. 2, 12, 20 have sunk panels; nos. 4, 7, 8, 13, 15, 16, 17, have flats separated by rounds; nos. 2, 19, terminate with reverse ogees; No. 5 has undercut quarter round; nos. 6, 9, 19, have reverse ogee with round; no. 9 has entire profile projecting from wall face, an except-

exceptionally permissible arrangement of heavy character. Nos. 15 and 17 with splayed bands.

In all these profiles the recalling of classic forms and the treatment of the architrave with imitated forms are suppressed as improper, and the nature of the architecture is brought into the foreground.

8. The so-called Ears.

Very ancient reminiscences of wooden construction remain to the present day in the peculiar forms of the so-called ears of the architraves of windows, if we conceive two window jambs, above which is placed a lintel connected below by a crosspiece (Fig. 318), we shall obtain the form of such an architrave in the simplest way; if we carry the moulding around the edges of the ears, the motive is enriched, and the architrave of the w window is harmoniously developed. The lintel (Fig. 319), which must project at least 0.9 inch, must have a height equal to t the width of the architrave; the window sill, which may also form an ear 0.9 inch high, should have about the same width, and since 1.38 inch is required for the wash, it must be 2.36 ins wider than the profile of the architrave. It is easly seen that only the outer members of the architrave mouldings can be broken around the ears, or at most only the principal band in addition to these, also that the sunk panels forming squares at the angles are unsuited for application to the ears like diamond panels, since ugly angles would be produced in the first case and ugly intersections in the last. (Fig. 320).

If it be desired to break the entire profile of the architrave around the ears, their height must be equal to twice the width of the profile (Fig. 321), but the jamb must then be about 0.9 in. thicker, since a part of the ear must be cut on it, or the lintel must be stilted about half the height of the ears. (Fig. 322. The last arrangements are awkward. It is permissible to increase the height of the ear by the width of its outer m moulding, so that the joint of the lintel cuts off a portion of the ear (Fig. 323), in which case the jamb must be about 0.9 in thicker.

It is to be noted here, that a variation of the arrangement of the ears, found in stucco work as well as in mitred wooden architraves, is only proper and justifiable in stone construc-

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construction, where no attention need be paid to the jointing and construction, as if the architecture were changed into sculpture, which is possible in the soft stone of Paris. In stucco or plaster work, one is entirely independent of the construction and hence may change the ears at pleasure.

To employ inclined jambs or to make their profile wider below than at top, so as to obtain space for the ears, would be archaic and scarcely justifiable in normal cases. It should also be remembered, that the height of the ears may be often determined by wall members, band-like friezes that run along the wall, or by the arrangement of mouldings having less projection than the ears (Fig. 324). The Rococo idea of placing drops under the ears to indicate that the window is in the Doric style is objectionable as being a pedantic fancy, like so many things devised by a mistaken classicism.

If a window jamb stands on a separate sill, which must naturally project from the wall sufficiently to give space for the jamb, the following cases become possible:- either the architrave moulding dies agains the sill (Fig. 326), against a low plinth (Fig. 327 a) or an inclined plane (Fig. 327 b), or its foot is concealed by an ornament, or lastly the moulding is returned (Fig. 327 d) so that its external band is a plinth.

The first and second arrangements mentioned have something undeveloped and incomplete; the termination of the moulding against an inclined plane was a special favorite in the middle ages and is the simplest and yet the most primitive form, suitable for the forms of jambs produced by splaying, its importance increases in case the moulding projects so much as to require splaying to carry off water, as on entrances of large size and similar architectural motives. Returning the moulding across the foot of the jamb is to be regarded as an invention of the Renaissance, and it may be single or double, either merely arranged on the front or also on the sides (Fig. 327,d,e). The most pleasing arrangement, though requiring most work in stonecutting, is that with the foot of the jamb concealed by an ornament, a mode of treatment much in favor in the German and French Renaissance.

ε. Window caps.

The most obvious expedient for enriching the appearance of a

window, at the same time protecting partly from the rain and balancing the sill, is the use of caps over the windows. A relieving arch is usually arranged above the architrave of the window, over which a cap may find room; this is then separated from the architrave by a space like a frieze (Fig. 328), if t the masonry is plastered, the relieving arch is concealed by the plastering, if constructed of ordinary materials; if the arch is carefully built of stone or brick it may remain visible and project beyond the surface of the plaster or face of wall; (Fig. 328); if the projection of the architrave be 1.38 ins., that of the frieze may be half as much. If the building is constructed of ashlar masonry, the relieving arch should consist of two or three ashlars, the last being cut in voussoir shape, (Fig. 329), or it should be concealed by a slab of stone that may be enclosed by a border, be decorated by relief ornaments, or be made of a nobler material.

The frieze must always project from the wall face it it is to act as such and if it be also of plaster; but it must have only the breadth of the window when ears are present, not to encroach on them. It is only justifiable to omit this frieze when the cap and lintel of the window are wrought from a single piece, and are therefore strong enough to support the weight of the wall, or when a special relieving arch is placed above them. The cap will then rest directly on the lintel of the window, from which it should always be separated by a visible joint (Fig. 330).

The cap is a horizontal stone slab built into the wall, which in the simplest way has a sloping wash at top and a drip at b bottom (Fig. 331 a). Its projection requires support by a lower moulding to make it satisfy the eye (Fig. 331 b), and a higher form of development needs a crown moulding (Fig. 331 c).

According to the projection of the cap with the same height, the vertical surface may predominate over the upper and lower members as in Fig. 331 b, c, or conversely it may be reduced to a minimum by them (Fig. 332). The entire character of the cap accommodates itself to this and will be heavy for a thick slab or light for a thin one. The appearance of caps of equal height may be modified by a steep or a more nearly horizontal wash.

The upper member (Fig. 333) fulfils the purpose of a terminating or crowning member, the lower one is a horizontal supporting one (Fig. 334); Evidently in richer arrangements these m members may be decorated by leaf mouldings, pearl beads, dentils and similar ornamental elements, according to circumstances.

One may take 7.48 ins. as a measure for the height of the cap in normal cases; if it is required to be lower the wash may be more inclined.

The projection of the cap may be increased as a whole by sliding the cap and its drip out farther; this mode of increasing the projection is dangerous, as the cap appears heavy in proportion to the entire architrave of the window, though not sufficiently protecting that from rain, at the same time it may appear to project too much at the ends. Caution is therefore advisable, and a moderate projection of the cap is preferable; its projection may be made less at its ends than its front, so that its underside appears unequal in breadth (Fig. 335), the upper and lower members projecting equally all round.

It is incorrect to regard a cap as a principal cornice at a reduced scale, as usually done; in many cases the cornice and cap may serve similar purposes, but on the other hand are essentially different frequently; The projecting cornice that c crowns the whole may serve as the terminal member for many objects, buildings and furniture, so that supporting or crowning, light of heavy, lower and upper members seem desirable without the need of a water spout, a leading feature of the cornice of the classic temple. By traditional custom the Greeks imitated the form of the water gutter where it could not be required, just as the mediaeval architects by force of habit also employed the so-called gargoyle when it was useless. The famous door of the Erechtheum at Athens, over which a regular cap first o occurs since the older Egyptian architecture, and which by the orthodox Neohellenists is esteemed to be of unique beauty! exhibits a mixture of refined sculpture and a lack of architectural thought. A cap of similar character, whose crowning member is changed into a formal water gutter; may be appropriate in certain cases if the crowning member is made a gutter of thin metal above a widely projecting geison of boards. But the imitated gutter is meaningless when a mare form and fulfils no purpose, and if the Greeks did become accustomed to regard the

cornice and water gutter as inseparable ideas, or in other words reached the false conclusion, that since a water gutter must be treated as a coowning member, conversely a crowning member must be shaped like a gutter, we need not imitate any nonsense of that kind.

In like manner the Gothic style committed the fault of using the very appropriate wash (or inclined plane surface) with its drip as a natural form of cornice, where no water was to be t thrown off. The Greeks employed a geison as the principal part of the cornice, making this project as far as possible, so that the shelter from the rain might be found beneath it. The middle ages feared torrents of rain but little and desired to rid themselves of the rain as rapidly as possible; in rather a short-sighted way, without sufficiently thinking of its disposal, whether any provision should be made for this or not. The need of a principal cornice exists for a wardrobe, stove or altar, just as much as for a house or tower; still in the first three cases it will act merely as a crowning member and not to carry off water. In the same way a cap may be required in the interior of a building, for furniture, niches in walls, for altars, monuments, doors and windows, stoves, etc., to satisfy esthetic requirements without fulfilling any material purpose. There always remains an affinity between a cap and a cornice if their purposes are allied, yet they are not the same, one remaining a cornice and the other a cap.

When a cap is required to have a considerable projection,with consoles of the simplest form it is that of a slab projecting strongly forward and supported by a corbel at each end (Fig. 336); to make these appear effectiv, the slab should project but little beyond them as much as may be necessary, while the ends may project more· the lower members of the cap are broken around the consoles,and underside of cap may be decorated by sunk panels to not seem too heavy.

The consoles may be placed above the lintel of the window or door; only occupying the height of the frieze; they will then have the same width as the architrave over which they are placed (Fig. 356), or are placed just outside the architrave that extends between them (Fig. 338); in this case a steep form is preferable, corresponding to the slender ness of the windowa

No absolutely valid rule can be given for their dimensions, b but a basis is to make their breadth 3.94 to 4.34 ins. and their total height 16.95 to 20.9 ins, exclusive of the lower member of the cap. These dimensions harmonize well with those given for architraves and those of the cap.

It should also be noted here, that the lower members of the cap, which are broken around the consoles, should be wrought on the cap itself, and therefore in profiling them attention must be paid to the form of the cap and also to that of the consoles.

When consoles are employed, a decoration of the frieze above the lintel is more justifiable, because it may be treated as an ornamental panel with peculiar propriety.

A further means of enriching window architecture consists in the arrangement of a window sill on which stand the jambs, and which partly serves a decorative purpose and is partly desirable on esthetic grounds, partly resulting from material needs.

5. Window sills.

As already stated, the window sill is a kind of cornice that projects sufficiently to receive the architrave, or at least 9.08 to 13.8 ins. for fully developed architrave mouldings. T This projection is so great as to require some lower members, since the sill would appear too heavy without them, and these lower members must be supports. If moulded jambs are used, the front surface of the sill would seem too heavy if left smooth' therefore it may be finished with sunk panels but most project more to afford the jambs a firm support (Fig. 339). This arrangement was already known to the classic period, examples being found on the Erechtheum a Athens and the temple of Vesta at Tivoli.

In our rainy North the sill must usually have a drip to prevent the water from running down the wall, and this end is more perfectly attained when the sill has an upper crowning member, which not only throws the water farther from the wall, than a simple slab would, but also lends the entire sill a richer and more noble appearance (Fig. 340). This upper member is generally returned at the ends of the sills; the result is that the water either runs down the wall at the angles of the sill, or special precautions must be taken to prevent this evil; a further

result therefore is that the sill is longer than the total width of the window. The simplest means of leading the water away from the wall consists in forming a small spherical wash at t the angles of the sill (Fig. 341), which is scarcely visible from,b elow. The widening of the sill resulting from the addition of an upper member makes of its upper surface a very convenient support for persons looking out of the window, for flowering plants, etc. To better satisfy similar requirements, the middle ages and Renaissance styles sometimes corbelled out sills; we shall return to this later. The following modes of arranging sills are those now most common.

1. The sill is isolated and not connected with other architectural details, to form a part of the enclosure of a window, simply projecting from the wall.

2. The sill projects from a continuous string course, either flat or along it are continued the upper, lower, or all members of the sill (Fig. 342).

3. The sill is supported by consoles.

4. The sill rests on a slight projection of wall under window.

5. The sill is formed as a low base, which may be connected with the base of the building in the basement story (Fig. 343).

1′. In the first case, the sill should have but moderate projection, only as much as absolutely necessary. Profiles like 1, 6, 7, 8, 9, in Fig. 343 may be suitable as applicable.

2′. If the continuous string cousse is flat and projects from the wall, the profile of the sill may spring directly from it, 1 to 9, Fig. 342, or this may project by the breadth of the lower horizontal fillet. A profile like 10 permits the sill to be made lower than the string course, while the lowest vertical fillet may coincide with the string course (Fig. 344). If the string course and sill are moulded alike, the sill either does not project and coincides with the string course; or it requires support by consoles, small pilasters or slight projection, or a projection of the wall surface in case it projects beyond the string course.

If the upper or lower members of the sill are omitted in the string course, it should have a greater projection and a more solid character than in the second case5 in the first it appears as a strongly projecting cornice, in the second as a lighter band with terminal or crowning members (Fig. 345).

The projection of the sill may then be obtained in different ways, either omitting the drip of string course, or supporting the sill on consoles, pilasters or a projection of the wall.

3′. If the sill be supported by consoles, the same general rules apply to them as to consoles of caps, they should have the same breadth as the architraves, beneath which they should be accurately placed; they enclose a space between them, if as often happens then rest on a base , or are connected by a small band under their lower ends (Fig. 346), and this frieze-like interspace affords opportunity for decoration by sunk panels of all kinds. The upper members of the consoles, when these are also lower members of the sill, require consideration in regard to both points. The underside of the sill, like that of the cap, may not only be decorated by sunk panels, coffers, etc., but must be so if the sill projects considerably, to reove the heavy character from the view of the underside.

4′. It will be deemed advisable in many cases to form a projection beneath the window, which not only gives it a more sl slender character and is therefore necessary, if the height of the window is small in proportion to its width; but also as b before seen, it is desirable for widely projecting sills, that it is not desirable or possible to support by consoles. These projections may be left smooth or be decorated by sunk panels of all kinds (Fig. 348), medallions, heads, wreaths, etc. and finally may be limited at each side by short pilasters, which enclose a sunk panel (Fig. 346, right half).

5′. The development of the sill as a low base may occur on different grounds. In cases usually found in houses it may be desirable to restrict the normal external height of the window projection to about 31.5 ins., partly being a wall, the remainder an iron lattice; this will be permissible if the windows of the best story be so arranged, that their sill forms a seat on the interior, above which is placed a balustrade of iron lattice work or a fixed window, to serve as a back, or a second window to serve as a back , or a second balustrade intended to support the arms.

This will further be the case if higher proportions are to be given to the low windows of a mezzanine or upper story; and finally if for special reasons it is desirable not to place the

string course as in normal cases, at the same height as the i inner beams but higher, for example to afford a stronger construction to the windows , and their relieving arches in the lower story. As a rule, the string course is then placed at the same height as the sill, but may be lower if required, and the sill then be formed like a low base (Fig. 343). It may be advisable to mention a fourth case, making the entire height 31.5 ins. of masonry, to insert a low projection between the sill and architrave, which is returned across below this panel (Fig. 347); finally a similar arrangement may be necessary or proper,for the reason that the base of the window in the basement story may be combined with the base of the building, and perhaps form a group with the cellar window also (Figs. 343, 349, 350). The drawings of forms of windows given in Figs. 349 to 350 are due to the Dresden school.

η.Abnormal forms of windows.

After discussing the windows of house architecture in accordance with normal requirements, we have to mention a few peculiar arrangements partly corresponding to the requirements of certain stories, partly employed in exceptional cases.

The Italian high Renaissance invented a form of window in a perhaps isolated case, which harmonizes with the rude character of rustic masonry without differing from the normal form in general. Antonio Sangallo the Younger desired to build himself a house, on the rusticated basement of which his invention should be employed; it consists of a simple treatment of the narrow architrave by means of flat bands and splayed surfaces, with the necessary rebate for the window shutters. The considerable thickness of the walls of a basement story afforded wide jambs and soffits to the windows, and consequently narrow architraves and these simple and severe profiles, of which a few varieties are given in Fig. 351, that are fully justified. For the same reasons, the rusticated windows of a basement story or of the shops are treated with simple architraves, which are based on the motives of a splayed surface (Fig. 352). Since the windows of shops generally require a special arrangement for the reception of iron shutters, the width of their architraves is increased by the wooden frame, and the space between the two, to receive the shutters of sheet iron. The simplest

mode of forming the sections of rusticated windows is to omit any special architrave; the rustication then either ends in f front of the jamb of the window or is returned around it, stopping against a reveal, which also determines its greatest projection (Fig. 353). A further simple form of window is a favorite in the Italian Renaissance, especially for modest buildings, or for subordinate windows. It consists in leaving the outer surface of the jamb flat, its inner edge only being bordered by a simple moulding, which may project beyond the flat surface as well as recede behind it (Fig. 354). From these two motives are developed two others and very pleasing ones by corbelling out the sill, and by carrying the flat architrave around it or not. The corbelled sill may be formed independently of the profile of the architrave (Fig. 355).

Another motive was derived from these and similar arrangements, consisting in decorating the outline forms of the outer band, especially with forms of volutes like consoles in connection with foliage and palm leaves, which were employed during the high Renaissance for the most diverse purposes and arrangements; to lend a decorative character to the smaller windows of mezzanine stories, or those intended to light the vaults of rooms, in contrast to the more severe forms of the windows of the principal stories (Figs. 356, 357). Roman buildings in particular employed this expedient.

From it was developed the inexhaustible motive of the enclosure of inserted sculptures by architraves, which were built into the walls, as if found by excavations on the site of the building, and which it was sought to harmonize with the most varied effects by combining all these decorative motives with caps, sills, consoles, and other window motives. This is not the place to go into all these details, principally borrowed from palace architecture, and reference must be made therefore to publications on Italian, French and German Renaissance, which afford a multitude of ideas, which may be used in rare cases.

Mezzanine windows usually have a greater width than height, are then sometimes divided by a central mullion, or they are square, or their height rarely exceeds their width. In exceptional cases, according to the architecture in which they are employed, they may take any suitable form other than the rect-

rectangular, be treated as wheel windows or formed in any other way (Fig. 359). The same is true of all smaller openings found in all classes of buildings.

8. Abnormal forms of caps.

Different requirements may exist, which in houses of several stories lead to dissatisfaction with simple forms of window caps and to a search for richer forms. The principal cause of this is always a desire to characterize the different stories of a building. Natural requirements and associated ideas have led to the treatment of the basement as the heavy, bold and s simple story; of the best story as the most prominent one as severe and noble, of the remaining stories as subordinate,and of the uppermost as the lightest and most graceful, requiring and capable of the most decoration, further a ground law of architectural treatment consists, as often stated, not in seeking variety and richness in change of motives alone, but in enhancement of motives. From the simple window architrave we have obtained the following series of motives.

1. Architraves without ears; 2, those with ears; 3, those with caps; 4, architraves with caps on consoles· 5, those with cap and sill; 6, architrave with cap and sill supported by corbels; 7, those with cap and a special projection of wall as a base below the window. An enhancement of the motive leads to 8, where an angular pediment cap is introduced; to 9 with circular pediment cap, these being of segmental form. The latter becomes 10 by interrupting the cap by an ornamental group. In exceptional cases, a cap receives an attic story for the reception of an inscription on tablet makink 11, or 12, a purely ornamental centrepiece (Fig. 360, a, b).

Let us take as an example a four story detached house (Fig. 361), which is to have four different facades, an unbroken principal facade next the street, that next the garden with a projection and the principal entrance, and two garden facades with projections; each story contains a small flat, consisting of kitchen and its appurtenances, toilet, dining room, reception room, living room, bedroom; three windows in each facade being sufficient. The house possesses ungraceful and very slender proportions; therefore the basement should be separated f from the other stories by a belt, and the opper story be treated

like a frieze, i.e., enclosed by a band, thus balancing the basement story. We now have to arrange so as to make the windows of the best story more prominent than those of any other story, so as to characterize this as being the best story. We should therefore furnish the windows of the first story with caps having consoles, connecting them by a light string course, to still more moderate the slender proportions of the house. One angle projection of the house contains the living room and is therefore subordinated; the other projection contains the dining room, and is so placed as to enlarge this and increase the varied effect of the whole. The living room is marked by a window with angular pediment. If we assume the dining room to have a balcony, the door to this balcony also serving as a window, would differ from the other windows and would therefore require its special distinction. To treat the windows of the kitchen, toilet and dining room more plainly than those remaining in the small flat will hardly be proper in an assumed case, when a pleasing appearance of the house is required on the garden side, for first the unity would suffer from too great variety, and second this inferior treatment would serve to indicate those rooms that should be ignored as much as possible.

The scale would be lowered some in the second story, the window of the living room in the projection would receive a cap without pediment, but with small consoles. The other windows of this story should have caps without consoles and should be without separate sills. Finally, the windows of the third story would merely have architraves and would produce sufficient effect by their connection with the frieze; yet the window of the living room may be distinguished by an ornamental cap. (Fig. 360). The windows of the basement will fulfil their purpose if they are of simple form, since the act in connection with the base of the house, and a more severe and simple treatment than that of the windows of the best story will be proper.

In case of a house with four facades, only two of them will be seen at the same time; hence unity and variety are to be considered in the two facades seen at the same time. The principal facade appears perfectly symmetrical in our example, since but a single kind of window is found in each story.

Together with the side facade, which has a projection for

the living room, variety of appearance is obtained by the enhancement of the motives of the windows' in the same way the side and read facades seen together form a group of varied but united effect. There still remains the description of the treatment of the doorway. This must have a transom for lighting the hall, according to circumstances. If the windows of the stair hall are arranged in the usual manner to not be at the same height as the windows of the stories, but with reference to the landings, this arrangement not only gives rise to many peculiar combinations with the string courses, but may perhaps exert an influence on the forms of the other facades. Especially since a harmony of the facades may only be obtained, when all motives occurring on them find their fullest development and resolution, so to speak, the arrangement of the stair windows assumed in our example conflicts with those of the other facades, and requires to be softened. The stair hall windows serve purposes other than those of the living rooms, and should therefore be esthetically treated in a different way. The lowest window here serves as a transmo for lighting the hall, and may receive a pediment cap, angular; or its place may be occupied by a tablet inscribed with name of the owner, date of erection, etc. The window above this has a decorated circular pediment, whose character is always less severe than that of an angular pediment cap. The uppermost window may have a purely decorative cap.

We have given a preliminary indication in this example, that may recur in inexhaustible variety, according to arrangement of plan and number of stories, according to the simpler or richer, mor modest or more pretentious character, how artistic expedients should be employed in a special case. The general grouud laws of contrast of effect and of internal and external truth determine our choice of the different motives of form, to start from certain normals and not to throw together motives at our fancy. The law of enhancement of motivesin connection with the other ground law, that a series of similar elements require the middle and ends to be made prominent as being special points, or that their recurrence in a periodic series must be accented, requires the strongest motives to characterize t the points, that are to be made most prominent, the weaker to

be subordinated, and further a strict adherence to simplifying the motive of the different stories, to a certain degree, and finally that as the painter mustfirst have a clear idea of the distribution of the brightest lights and deepest shades over his picture, one must not in the arrangement fose sight of the highest and lowest permissible limits, within which his motives may be chosen.

Thus in case of a villa consisting merely of a basement and first story, it would be in accordance with the means at our disposal, and also with the character of the building, to select for the windows of the best story, which local cirmumstances place in the basement, a stronger or richer motive of form, than for the other story; a winow with a cap and sill, both on consoles, would usually be sufficient for the richer designs; but the stronger motive of the angular pediment or the weaker one of a decorated cap, would be restricted to those windows of the same story, which are tobe specially characterized; thus the strongest motive must not be selected for the general one, leaving no means remaining for distinguishing special cases, requiring one to descend to a lesser motive. In the same way, the forms of the other and subordinate story should be reduced a degree, so that the best story may have its due effect. If the basement be also the best story, a combination of the architecture of the windows with the base and the cellar windows in a grouped motive, or the combined effect of these elements as a whole, even if not connected, will appear to bold and so rich, that the sills do not require the additional effect of corbels.

The windows of the upper story, in which are thebedrooms, b breakfast room, nursery, dressing rooms and guest rooms, while the best story contain the rooms for social purposes as well as the room of the master, the common living room, etc., should be treated in a subordinate wayandbe simpler, therefore lighter and less severe.

Conversely, if the best story be the upper one and the ground floor be assigned to inferior purposes, the basement must be simply and boldly treated and be heavier, while the upper story requires richer and yet strong and elegant forms.

The Italian Renaissance may be reproached with having retain-

retained the Doric, Ionic and Corinthian orders, as a fixed series of the characters of the stories, and called the circular d pediment Ionic and the Angular one Corinthian, forgetting that in comparing round and angular pediments of equal height, the round pediment always possesses the character of heaviness with less strength than the angular one; thence resulted a contradiction in the architecture of many palaces and houses, if Doric columns were employedin the basement and Ionic in the first story, but with alternating circular and angular pediments, as in the Pandolphini palace, Raphael's famous building at Florence. The alternation of round and angular pediment caps in the same story h has its advantages in general, if the story contains more than three windows. a certain contradiction remains even in this case, as may be seen on the facade of the Bartolini palace at Florence; the stronger motives are too much concentrated. If the caps alternated in case of four windows, as in the Pandolphini palace at Florence, and the Farnese palace at Rome, a doubly ungraceful result is produced, since the ends are different without any reason therefor, and the middle is not accented. An alternation would first become suitable in case of five windows, especially if angular pediment caps were used at middle and ends, with circular pediments over the intermediate windows. Palladio employed this expedient in his beautiful Chieragati palace at Verona with good results. In case of a longer series of windows, round and angular pediments hshould preferably only be employed as a means of strengthening the centre and ends. The adjoined schemes (Fig. 362) give examples of ways; in which a change of motives is admissible in different cases, without injury to the unity or variety.

e. Forms of Pediment Caps.

As for the forms of angular and circular pediment caps, their heights may be made about 1/4 to 2/9 of their spans. The mouldings of angular and curved pediments are similar to those of horizontal caps; the two following cases may occur; the upper or crowning member is either merely carried around the pediment cap, and omitted on the horizontal return, which terminates at top merely with the member connecting the facia and the crown moulding, or the entire moulding is carried along the horizontal cornice on which rests the moulded gable, and stops against a slightly inclined plane. In the first case, the intermediate

fillet encloses the tympanum; in the last this is done by the upper fillet b.(Fig. 363).

The upper member a, if it be fully developed in front as well as sidewise, requires to be slightly broken at the angle of the cap, which in reality is less disturbing, than if this be omitted and the profile be distorted at the angle.

The vacant space enclosed by the mouldings of a circular or angular pediment, is properly decorated by an ornament, a shield of arms, head, wreath, decorative sculptures, etc. (Fig. 364), so as not to produce the impression of emptiness and heaviness; the background of this tympanum may project beyond the face of the wall in case the pediment is supported by consoles.

The classic and the Renaissance styles gave the same profile to angular and circular pediments as to horizontal caps, on which they rest. Strictly speaking, this is unnecessary; the pediment is always something different from the horizontal cap, and in many cases, it has too heavy an effect, if both have the same profile, in the horizontal cap the geison is the principal thing, but this is of secondary importance in the pediment, and the crown mould of the curved or angular pediments will take the first place as being the crowning member of the entire window, and the geison plays a subordinate part; it will therefore not be unjustifiable to make the geison of the angular or curved pediment narrower than that of the horizontal cap, to allow the crown mould of the former to predominate, but the latter to end with merely a terminal member, and to form the supporting lower member of a pediment lighter than that of the horizontal cap (Fig. 365).

Broken circular pediments are produced by accenting the middle of the arch by a grouped ornament of any kind (foliage, suspended garlands, wreaths, shields of arms, vases, palmations, heads etc.), which are placed between the volute-like ends of the broken curve (Fig. 366). The upper fillet of the crowning member is curved around the eye, formed like a rosette, against which and the ornament die the other members. These broken circular pediment caps, which are properly nothing else that ornamental crownings above a horizontal cap, permit a free treatment, which may be varied in accordance with the period in which they are used.

If it be justifiable to break the less severe circular pediment caps and to give them a decorative character, on the contrary the breaking of the angular pediments at the apex, a favorite idea in late Roman and late Renaissance art, so that a bust or other sculpture may project above its apex, is an objectionable expedient of a degenerate art, which passes beyond its natural limits. A given motive may not be modified or enhanced at pleasure, but only within certain limits prescribed by its purpose. Many things indeed exist, which according to general principles are more or less pleasingly formed, but the justification of their existence is not based on their pleasing appearance., but on the purpose which they may serve, as we have fully stated. This pleasing effect only takes the first place in free ornament.

x. Cap with Consoles.

If the caps are supported by corbels, these flank the jambs on either side. The ears are then best omitted. The consoles project directly from the wall face or from a pilaster of equal width, which may be flat or be bordered by an architrave moulding (Fig. 367). The breadth of this pilaster will be decided by the fact that the console, to appear capable of supporting the cap, must have a greater height than breadth; the higher it is, the narrower it may be, but the lower it is, the wider it should be. The breadth of the pilaster must be determined accordingly, but in normal cases it will be narrower than the architrave of the window. If the projection be broad in case of relatively low consoles, the architrave of the window must be made proportionally narrower, as in Fig. 367, since the entire finish of the window would otherwise appear too wide in proportion to the clear width of the window.

This pilaster always requires some projection from the wall face, and paneled ashlars may not therefore abut against it, but must be separated from it by a margin. If the window has a base beneath the sill, the pilasters require separate bases.

The effect of the pilasters will vary in accordance with their sections, and according to whether they are behind the band of the architrave or in the same plane with it. If one desires to lessen the projection of the caps of the windows at each end, the consoles may be placed directly above the jambs

and the lintel of the window, so as to enclose the frieze between them (Fig. 366). They then take the same breadth as the jambs, and their projection is determined by their section.

The consoles themselves, as we have seen, are either low and broad as in Figs. 366, 367, 368 and 369, or are high and narrow, as in Figs. 364, 370 and 371. Consoles resting on a base and supporting a sill may be arranged as in Fig. 372.

In corbels under sills, a difference is to be made, whether they stand beneath the architrave (Fig. 370) or under a pilaster as in Fig. 371. a further difference consists in their being upright as in Figs. 366, 367, or suspended as in Figs. 368, 369, i.e., whether the eye about which is coiled the volute is above or below. For pediment caps, narrow and high consoles as in Fig. 364, are preferable to broad and low ones, which are more suitable for lighter caps and sills.

Balcony consoles, two examples of which have been given in Fig. 373 and 374, generally require strong projections of a bold character. It will frequently be necessary to arrange several consoles above each other like corbels, so that each supports the one next above itself. This is particularly necessary in designing bay windows, which require strong supports, not for structural but for esthetic reasons. Such corbelled arrangements may be most simply profiled by being allowed to project slightly sidewise and strongly in front (Fig. 375); d decorative forms may be employed instead of mouldings.

For ordinary house construction, using cut stone, a horizontal window lintel is most suitable for practical and esthetic reasons. Even in brick construction, for which the straight a arch may be used, one prefers not to employ arched windows in the construction of houses, at least not for living rooms, but for stairway halls; for practical reasons because arched windows admit less light than if rectangular and of equal height, and for esthetic reasons since it is to give the house a character differing from that of palaces and public buildings. For the same reasons, one should be satisfied in house construction with the modest artistic expedients already described, and reserve richer and bolder forms for public buildings and palaces.

2. Windows of public buildings and palaces.

For the architecture of the windows of public buildings and

palaces, the determining consideration of the first importance is that the windows are generally larger and light rooms of a greater depth, than in houses, and further that the external walls are thicker. Consequently the windows require greater width and height, their jambs are wider and their axial distances are greater. These buildings from the requirements that they fulfil are also on a larger scale, more solid and massive than are usually houses, and therefore require bolder artistic expedients than they do. The greater width of the windows is first of all, since this has a decided effect. If the windows are rectangular, careful attention must be paid to removing the load from the lintel, which must have a greater height than lintels of windows in houses, so as not to break at its middle. In simple ashlar masonry, the lintel will be a single block, to relieve it the stones lying above it must be supported by corbelling and radial jointing (Fig. 376). If jambs are used, it may happen that a frieze is formed below or above the architrave moulding as at a or b, Fig. 376. A perfectly corresponding case is that in which the lintel of the window forms a complete entablature supported by pilasters, which like itself projectfrom the wall face. (Fig. 377). This entablature has its crowning cornice, with or without pediment; a separate architrave composed of two jambs and a lintel may enclose the opening. If the pilasters are replaced by columns, we obtain the canopy window, such a favorite in the high Renaissance, w with all its consequences, the pedestal, perforated parapet, etc. But this window architecture requires either a bold recession of the stories to allow the columns and their pedestals to stand free in front of the face of the wall, or the pedestals of the columns must again be supported by columns, consoles or caryatids. Finally this window motive may be developed into complete bay windows, enriched by doubling the columns, or by the aid of pilasters, or may be changed into the frequently employed loggia motive py the introduction of arches over pilasters or columns.

The arched window is developed in the simplest way from ashlar construction. Reference is here made to the general statements concerning openings in walls made under a. The palace architecture of the Italian Renaissance developed the arched

window in the most complete manner; the arches are absolutely required by the great spans of the windows. As previously stated, its form results from the principle of construction, either a special stone architrave beind formed, which projects from the wall face, and which may be crowned by an entablature and pediment or a circular cap, or the archivolt moulding is wrought on the ashlars themselves. If the window is so large that the glass requires intermediate divisions, these are provided by the use of small columns or pilasters, which limit the openings in the window, the motives of the windows of the early Florentine palaces. the small columns are covered by a horizontal lintel or spanned by arches, the tympanum over them being perforated, so that a kind of window tracery is produced, with the same meaning as that of the middle ages. If the window consists of three divisionsit naturally results, in case no horizontal lintel is used, that the middle part is made as high as possible, and the spandrels are filled by circles (Fig. 378 a). In case of a horizontal lintel, a large circle in the center with a smaller one at each side is an appropriate arrangement. (Fig. 378 b).

A horizontal lintel (Fig. 378 b) does not generally look well, if the tympanum of the window is filled by circles or by other closed figures, since the tangency of a complete circle and a straight line is less good esthetically, than if it were tangent to one or more curved lines. One of the best proportions for windows of three divisions is obtained by dividing the diameter in three equal parts, describing small cirtles on 1/3 the diameter next each springing, theyn drawing a larger circle between them and the semicircle, letting the semicircles of each division of the window be tangent to these three circles (Figa 378 c). The springing points are thereby lowered, and the upper tracery gains in importance.

Another motive for dividing windows in two or three parts, only applicable to rectangular windows, is to place horizontal lintels above the window jambs, forming transom lights above them by means of short pilasters connected by horizontal lintels also. (Fig. 379 a). This arrangement is particularly justified when the transoms are fixed, only the lower portion of t the window being ope ed. The central vertical mullion may then

be treated as a supporting pilaster. In windows of this kind, containing three divisions, the central transom bar may be omitted, so as to make the central window higher than the side windows. The different mullions may likewise support circles and semicircles (Fig. 370 b).

3. The Curch Window.

The church window falls outside the limit of ordinary construction, both from its considerable dimensions and especially by its height, as well as by its purpose of lighting the House of God, and must avoid everything of a secular naturein its appearance; therefore all decorative expedients must be avoided, which tend to recall the construction of houses and palaces. The considerable thickness of the walls afford broad jambs,that are usually splayed with or without mouldings. If the windows are not simple openings between piers or columns supporting entablatures, but are spanned by arches, all the forms of arches permissible in secular architecture are to be excluded, w with the exception of the indispensable semicircular and pointed arches, which if slightly pointed or a depressed pointed arch, is always appropriate in church architectwre, if a certain effect is to be produced. For church architecture, unless the forms of classic temples are not capriciously introduced therein, will always return to the forms introduced by the middle ages, more than secular architecture, assuming that the constructive principle is to govern. On esthetic grounds, the pointed arch retains its superiority over the circular arch, if properly used. Thus in a group of three church entrances or church windows, a pointed arch between two semicircular ones gives a more varied appearance, than three semicircular arches side by side. On the other hand in using the pointed arch, we are not obliged to accept all the consequences which resulted from it in Gothic. If we do not desire to build exactly in the Gothic style, but to rationally derive the architectural forms from structural and esthetic requirements, still in many special questions of church architecture, we shall touch on the Gothic style, but must before all else avoid everything specific to that style, and which may as well or even better be replaced by other forms.

4. The Wheel Window.

We can never exclude the wheel window from church architecture. It always remains that form of window most pleasing and most suitable for certain purposes. In case the wheel window is not divided by an iron framework, on account of the glazing but by stone work, one should always recur to the motives common in the middle ages, and either arrange radial mullions around a centre, whose outer ends are connected by arches in any way, or a system of perforated slabs are arranged about a centre, in which the detail forms specially belonging to the Gothic and Romanesque styles should be very carefully avoided. Thus a circle is a general form always required in architecture, but the foils and cusps of Gothic tracery being specific, are no longer necessary in church architecture. A scroll work of plant stems may be employed as a motive for the tracery of church w windows, in which the jointing may be horizontal, or be arranged in accordance with the principles of arched construction.

In this way may be invented tracery, whose form entirely corresponds to the principle of the Renaissance style, while its construction and mouldings is in accordance with the mediaewal principle.

5. Window Tracery.

Vertical divisions of windows may form a system of mullions like those of mediaeval tracery, or a system of perforated horizontal slabs of stone be placed on each other. In this case likewise, the form principle of the Renaissance admits of the most varied forms, scroll work, tapestry patterns, the use of figures, plane and ornamental decorations of all kinds. The mouldings are similar in principle to those of mediaeval styles, even permitting a freer treatment. A freer form of the patterns of window tracery is suitable for the Christian church, a more strictly geometrical one for the synagogue, without the necessity of borrowing from the Moorish style. After the classic m method it is possible to divide windows by placing pilasters above each other, which support horizontal intermediate cornices and are connected by arches (Fig. 381). These cornices require a wash on top. The lower part of the church window best stands on a splay (Fig. 382), which carries off the water, and ends with a drip moulding, that keeps the water off the wall.

6. Transom Windows and Skylights.

Small windows frequently serve to light the upper galleries of halls, as well as the ceiling. If they are not windows of ordinary and normal form, they may take different forms according to what may be permitted by the external architecture, circular or oblong, with angles cut off, semicircular, etc. They always play a subordinate part and are preferably decorated in accordance with the arrangement of the facade. They are sometimes placed in the frieze under the roof cornice or its entablature.

7 and 8. Doors and Gateways.

For doors and gateways of rooms, public buildings, palaces and churches, the same is applicable, which was said under a on openings in general in walls, and a portion of that stated in regard to windows. In the simplest way, the door is merely enclosed by an architrave, either with jambs and a lintel projecting from the wall face, or by mouldings which recede behind the wall face and are wrought on the ashlars. The architrave should be changed below into a kind of plinth by some means, either simply dying against it or returned around it.

The section of the architrave should have 1/7 to 1/2 the clear width of the width of the doorway. In the early Florentine palaces with their massive bossed ashlars, the breadth of the architrave is about half that of the door. Evidently the doorway will appear weakly or strongly protected, according to the width of the architrave, and a strong protection will appear the more desirable, the greater the opening of the doorway, and may become the principal motive of the artistic treatment of a city or fortress gate, a tunnel, or a gateway bridge.

Simple rectangular doors with horizontal lintels yield the following series of motives with the aid of the columnar order.

1. The architrave has an added frieze and cap; the progressive additions for enriching this motive are:- consoles under the cap, pilasters on which rise the consoles, a pediment, an attic story, or a transom window above a cap, additions which admit of the most manifold variations of form, according to t the special circumstances.

2. The architrave of the door is flanked by pilasters of columns, which support an entablature. The pilasters or columns may be with or without pedestals, may be arranged in pairs, the

entablature may be covered by a pediment, or may form a balcony.

Doors and gateways covered by arches admit of a series of motives, from the simplest to the richest case, with enrichments by the expedients already mentioned, especially by making the springing blocks and keystones prominent. If paneled ashlars be added, as in many palaces, or three gateways are connected in a group, the richest forms are produced, like those invented by the Italian Renaissance in palaces, gates of fortifications and cities, and also those erected in our time. The last named motiva of the triumphal arch may be varied in different ways, according to whether the openings are of equal widths, or the middle one is widest, or whether coupled pilasters or columns with or without pedestals are used, and from this by placing a second one over the first was derived the motive of a two-story triumphal arch employed iy many Renaissance churches. The motive of the triumphal arch is likewise best suited to magnificent city gates and will so remain, since the central opening of wider span for carriages, and the narrower side openings for persons on foot, can scarcely be more properly c combined in a group otherwise than in this way. By the addition of an attic, a crowning group of figures, and especially of sculptured decorations, or lastly by flanking it with two successive towers, the motive of the triumphal arch forms a d decorative architectural work of the first rank, which may as well be employed as a motive for a city gate, or the portal of a bridge, as for the facade of a church.

In houses, palaces or public buildings, where the plan permits, should be arranged a small porch before the entrance doorway (Fig. 383 a, b), or a projecting porch is constructed, which supports a balcony or terrace. Both arrangements admit of the most varied forms, according to their connection with the other architecture.

Such porches are much used at the principal entrances of churches, and are often indispensable on account of protection from wind and weather. They are then placed between two towers, or form the lower story of a tower, or lastly they project from the facade. On account of the thickness of the walls, the portals of churches always have very wide jambs, which should be treated in accordance with what was said under a in general.

They should always have more or less nearly approximate the church portals of the Romanesque style in their external form, yet avoiding all that could recall them. This is caused by the given conditions, which lead to like results under similar circumstances.

9. Portals of Tunnels, Culverts, Gateway Bridges, O Openings for Ventilation, Embrasures, etc.

All openings in walls comprised under this title and serving purely material needsusually require but a small amount of decoration, which is entirely dependent on the part played by the building or structure. In a city, tunnels, gate bridges, other bridges and fortifications, require greater expenditure for a architectural purposes, than if in a wild mountain solitude; but even the least of such necessary buildings must fulfil their purpose in the most complete way, and a form must be given to them by the human intellect, beyond the requirements of absolute necessity.

Tunnels for railways, canals or other highways, will always be located where stone is to be found, suitable for structural purposes. They are openings that require to be enclosed, and since they are almost always arched, this arch will of itself form the enclosure. Rusticated ashlars, bold archivolt mouldings, a prominence of the springing and key stones of the arch, will form the most natural expedients for their decoration. Facades are sometimes built in front of tunnels, which may be crowned by a cornice with battlements or a parapet flanked by angle towers, and decorated by shields of arms and inscribed tablets. In general, all superfluous decoration is to be avoided, in case it is not in a city and is also exposed to view of persons on foot. The time for observing the architecture of a tunnel while traveling on a railway is usually so brief, the change of impressions is so rapid while in motion, that the portal of the tunnel is only momentarily seen and its form is quickly forgotten. It is somewhat different if a street extends along the railway, so that persons on foot have time and opportunity for examining the structure.

It is generally advisable in engineering works and fortifications for sake of economy, to make the most extensive use of rock faced ashlar masonry. From it such structures derive a

character of earnestness and strength. All pretty forms are entirely forbidden in this case, since they do not harmonize with the character of these usually massive structures.

Battlements are always suitable as a crowning member of walls because forming a simple and effective motive. For the projections of cornices, massive corbels, corbelling like that under a bay window and similar expedients of the mason's and stonecutter's art are suitable. See Chapter on City Gates.

Embrasures, openings for ventilation and similar subordinate openings in walls, openings for discharge of water, etc., are best left simple and just as required by their purposes, without further development. It lies in the nature of the case, that openings in walls should be treated in accordance with t their importance and location. The more subordinate their importance, the less emphasis should be laid on making their forms more elaborate, than is required by the material need, therefore avoiding all that might appear pretentious. The solidity of the masonry must be the predominating means with careful execution, which determines the appeaaance of the building. The Barocco period indeed went so far as to decorate the embrasures of fortifications, one of many errors that we must avoid.

E. FLOORS.

1. Stone Pavements.

Stone pavements for streets, squares and courtyards, etc. are either composed of specially prepared paving stones, or of stones from rivers, or of buarried stones. In our era stone pavements are seldom employed for which a decorative appearance is intended. When such is desired, paving blocks of two colors a are used, by the aid of which simple enclosed panels may be f formed; the stones must evidently all be of equal hardness. In earlier times such pavements were made of stones of different shapes, i.e., of cubes and oblong forms. Such a pavement is f found on the cathedral hill in Trieste (Fig. 384) and a similar one is in Rome.

Pleasing pavements have been constructed in different places, of river stones and broken stones, which must all have approximately the same size. Generally square panels are formed with the larger stones, whose diagonals are also indicated, or oblong panels are filled by closely set paving blocks. If the river

stones are long and oval, they are usually laid in the pavement in herringbone bond. Separate figures may be composed of small stones with river or broken stones in pavements like mosaics. Fine examples of such pavements are to be found in Freiburg in Baden, in the greatest variety of patterns, very carefully constructed of river stones and with separate figures like mosaics.

2. Floors of Stone Slabs.

The simplest kind of floors of stone slabs, also employed for entire pavements of cities, is that composed of stone blocks like the ancient street pavements. In this respect the polygonal pavements of the City of Florence are imposing, with their very large and carefully set slabs and blocks of stone.

Square slabs are much used for covering the floors of churches, vestibules, corridors and passages, courtyards, etc. A favorite method is to use differently colored kinds of marble to produce patterns like mosaics. A specimen of ancient stone intersia from S. Gereon in Cologne is composed of Rhenish slate, into which are inserted figures of Brohlthal tufa; a second one from the same place consists of slabs of white sandstone, in which are regularly inlaid figures of red and green porthyry. Intarsias and mosaic floors may represent geometrical or ornamental tapestry patterns, or even figure compositions, as in many Pompeian houses and in the cathedral of Siena.

3. Floors of Bricks and Tiles.

Ordinary brick paving is always laid in regular bond, and the ornamental bonds are recommended for bricks set on edge, which produce patterns of all kinds. If it is desirable to employ colored bricks, they must not be enameled, but must be entirely self colored, so as to retain their appearance after use and to prevent slipping. It is not only permissible but even proper to make brick pavements of moulded blocks, whose forms are suited to a mosaic system. Especially those with congruent figure elements, to accent the solidity. Artificial stone may also be used instead of bricks if composed of very hard materials. These are used in the most varied geometrical patterns. Either flat pressed, raised or sunken tiles are employed for tile floors. The first may have the pattern burnt on in different colors, as on the Mettlach tiles. The patterns always form a network like tapestry, in case of either flat or

pressed tiles, whose forms depend on the stamp by which they are impressed. The same ground principles are applicable to tiles set in walls, only that glazed or vitrified tiles should de used, that are less suitable for pavements because of the danger of slipping.

4. Floors of Artificial Stone.

Concrete floors are composed of concrete, cement, or gypsum, laid on a bottom layer of bricks. A pattern may be produced by mixing different colors in the mess. A very suitable treatment is that employed in Michelangelo's Library of S. Lorenzo at Florence, where the forms of the floor are directly based on those of the ceiling.

5. Wooden Floors.

The only wooden floors here mentioned will be those of parquetry. They are either solid, i.e., composed of matched pieces of wood, or are veneered. In all cases they are wood mosaics or intarsias, which determines their form and prescribes their limitations. The mosaic system is especially suited to determine the forms of veneered floors, since the separate elements are cut from blocks, having the corresponding cross sections.

F. TREATMENT OF THE MASS OF A BUILDING.

1. Height and Character of the Stories.

The heights of the stories are determined by the heights of the rooms, and these depend on their areas. An old school rule gives us a basis, that the height of a room should equal 2/3 to 3/4 its width, or its $\frac{\text{length + breadth}}{2}$, or the half diagonal of the plan. These ratios afford starting points that may often be useful. The Baukunde der Architekten, II, p. 76, gives 7.4 to 9.8 ft as the least height of living rooms for human beings; the largest and finest room of a house, that is 19.7 × 29.5 ft., will not appear too low if its height be 14.75 ft. The proportions for houses and villas introduced by the Dresden school may be used as average proportions. The depth of the f front rooms is assumed to be 19.7 to 21.3 ft., and the height of stories is measured from top to top of floor; for the basement story of a detached villa, 13.96 ft.; for its upper story 12.15 ft.; for a city house with shops in the basement story, the heights of stories from below upward are 14.8, 13.95, 13.45,

and 12.8 ft. In case the depth of the front rooms be 14.8 ft., the above mentioned book gives 10.5 to 11.45 ft. as the height of story for houses for renting. In Vienna and Berlin are to be found stories of 16 ft. and over. At least 5.9 ft. is necessary for the clear height of rooms in mezzanine stories. The principal stories of palaces and chateaus measure from 16.4 to 36.15 ft. from floor to floor.

Building.	Basement.	Main Story.
Dresden, Oppenheim Palace	16.20	16.60 ft.
Berlin, Royal Palace	20.00	21.50
Berlin, Conrad's House	15.40	17.70
Dresden, Kapher Palace	17.20	18.40
Berlin, Old Palace (Schloss)		23.00
Caserta, Royal Palace		26.25
Paris, Louvre		27.85
Florence, Strozzi Palace		30.20
Rome, Farnese Palace		29.50
Florence, Pitti Palace		36.10

This extract from Baukunde, II, p. 75, gives a series of well known palaces, the heights of whose stories may be taken as normals for public buildings also. School rooms must be at least 11.5 ft. high in the clear, or 13.1 ft. for classes of 100 pupils. The large hall or singing hall must be at least 16.4 ft. high. The preceding heights of the stories of palaces are intimately connected with their external architecture.

The external character of the storier, their purposes and t their heights, are always intimately connected. The cellar story of houses or of public buildings, will always be subordinate, even if containing living rooms. Its height does not exceed that of the base of the building, and it requires a plain and massive treatment.

The basement may have a different purpose. It is occupied by shops in city houses, which require the widest show windows possible, or by modest city dwellings. It is very commonly the principal story of villas, as we have already seen, and contains the rooms for social purposes, while the upper story is occupied by bedrooms, rooms for guests, nursery, etc. In the last case, the basement is always the most richly decorated story.

The first story is generally the principal story, both in

houses for rental, as well as in palaces and public buildings, and its external appearance must therefore express this in its architecture. Consequently it will be most richly and elegantly treated, while the basement is simple and massive. If a mezzanine story is added, it must be treated with discretion, like the first story.

A second or third story always plays a subordinate part. In large houses for rental, these stories contain perhaps two or three separate flats, while the principal story contains only a single dwelling of high character. The second and third stories are accordingly to be more simply treated.

An uppermost story, that contrasts with the basement in buildings of three or more stories, should in very many cases be formed like a wide band connected with the principal cornice, and terminating the building at its top in a characteristic way. Since it usually appears too low and light in comparison with the heavy masses of the lower story, it should also be m more lightly and ornamentally treated, and it may frequently be connected with dormer windows or crowning gables. To connect together the windows of the upper story, wall panels, niches with figures, arcades etc. are arranged.

An attic may be placed above the principal cornice, behind which is concealed a story in the roof, or it may be characterized by dormer windows, or a so-called mansard roof may be constructed.

In rare cases the upper story of a house containing several stories is the principal story, as in many Italian cities, where the best story is placed at the top on account of the fresh air and fine view, while the lower stories are devoted to subordinate purposes, offices or less expensive dwellings.

2. Water Tables, String Courses and Cornices.

α. Water Tables.

Most buildings are limited at bottom by a base, which forms the transition from the masonry of the foundation to that of the basement and projects in front of the wall face by about the difference in the thickness of the walls. If cellar windows are employed, they can be arranged in the base, which extends around the building like a wide band.

The base most properly begins with a broad member and is cr-

crowned by a cap, above which begins the lower part of the lower story (Fig. 385 a). The top of this cap is at the same height as the top of the beams of the internal floor. The lower member is usually seperated from the die of the base by a base member (Fig. 385 b), and is inclined if necessary; the cap is also with a crowning member and a supporting lower member (Fig. 385 c); its upper surface is inclined, and its edge may also be inclined forward (Fig. 385 d). Above the wash of the cap is placed the base member froper of the wall, which may be broken around any existing projections beneath windows. These projections may be formed in different ways, as we have already seen, according as their external appearance is to be relatively high or low, and if a separate window sill is arranged, this with the base member may be changed into a second base above the cap of the base proper. In given cases many special solutions may be derived from the internal requirements, a few specimens of which are given in Figs. 343, 348 and 350, from Professor Nicolai of the Dresden school.

In palaces and public buildings, the base assumes a greater importance, and avails itself of stronger means of expression. In a few Florentine palaces, it projects considerably as a seat. The bases of churches generally require a strong projection to correspond to their considerable height.

In cities where dwellings are found in cellars, the base often has a considerable height to afford a greater height of w windows. It is not possible to go into the endless number of distinct solutions of the formation of the bases of buildings, to place them under a common point of view. There sometimes exist diversities in the ground, peculiar dispositions in the plan, the connection of the base with the principal entrance, with terraces or external steps, which lead to special arrangements. Projections of the masonry, columns, pilasters, with or without pedestals, influence the form of the base, as well as rusticated masonry, which is much used for the base, further cellar and subcellar windows, etc., windows of crypts in churches, etc. The base will always be modified according to the form, arrangement and proportions of the windows of the basement story.

A considerable influence is then exercised by the fact, whe-

whether the spaces under the windows project or are recessed back of the wall face. Also by the arrangement of shops, whose large show windows render a low base desirable.

A base will be in place in the principal story in many cases. It then usually has a slight projection and consists of a plinth, and a flat or moulded and decorated band, whose height corresponds to that of the window sills.

Flust or slightly projecting string courses with upper and lower members may appropriately be used at the height of the window sills and caps, at the ears in rectangular, or the height of the springing of the arches over round headed windows; they subdivide the stories in smaller divisions, and may be desirable for producing an animated division of the wall.

β. String Courses.

String courses are sometimes employed for separating the stories. At least the principal story must be separated by a string course from the one next below it, or if it be itself the basement story, from the one next above. Whether all the stories should be saparated by string courses or not, will be decided by the number and character of the stories as well as the length of the building. If a ruled appearance of the building is to be avoided in four or five story buildings, perhaps only the basement story with the mezzanine may be separated from the principal story by a string course, and the upper story be divided in the same way from those beneath it.

The forms of string courses should be as different as possible from those of the cornice; therefore they should have no greatter projection than necessary, so as not to conceal the lower part of the next story by their projection. The larger string courses that separate the principal story from that next below, usually consist of a geison with water drip, upper and lower mouldings (Fig. 386). The string course will appear heavier or lighter according to the prominence of the geison and the forms of the members. It will be enriched and strengthened by the introduction of dentils. The string course must always have an inclined upper surface to lead off the water, with on without a cove, by which the effective height of the course may be reduced.

In richer designs, the string course may be separated from the wall by a frieze, beneath which may be a bordering member.

The string courses of the other stories must be kept less p prominent and be diffeeently profiled from the principal one, either by increasing the upper and lower members so as to diminish the height of the facia, or by rplacing it by a quarter round or cove, or lastly by forming the string course at pleasure, composing it from the proper elementary forms in a suitable way (Fig. 367). These string.courses may also be combined with a frieze.

To decorate the separate parts of string courses by means of the expedients of antique architecture would not be normal in stone construction and for houses on account of the expense. It must be required, that it looks well without decorative accessories. On the contrary, this luxury may be allowed in public buildings, palaces and churches, according to circumstances and the principal stress is to be laid on the fact, that these ornaments also contribute to the effect; therefore we shall do well with plain buildings under the weak sunshine of our North, and with the darkening of stone in consequence of the abundant coal smoke, not to lose ourselves in the finesse of Grecian ornamentation, but to adhere more closely to the severe forms of Roman and Renaissance architecture as models. Since we have n neither Greek proportions, strong light nor noble marble, we must make allowances for conditions entirely different.

γ. Cornices.

The main cornice has the material purpose of protecting the masonry from rain as much as possible, as well as to receive a gutter, and the ideal one of terminating and crowning the top of the building. The height of the cornice depends on the effect to be produced, its projection, or how far the material employed may freely project. The higher the cornice, the lower will the building appear in proportion, and the lower it is, higher will seem the building. The fewer the number of stories in a building, the less necessity exists for the cornice to appear high. Therefore the cornices of low buildings should be proportionally high, and of high ones low. The following buildings of the Italian Renaissance may serve as guides. The height of the cornice without the frieze, measured from the bottom of the lowest to the top of the highest member, is as follows, compared to the total height of the building. Villa

Farnesina, 1/20; Pandolphini palace, 1/14; Strozzi palace, 1/16; Gondi palace, 1/18. The entire cornice including architrave and frieze amounts to about 1/21 of the total height in the Cancellaria at Rome, 1/16 in the Rucellai palace, 1/8 in Villa Farnesina and the Pandolphini palace, about 2/13 in the library of S. Mark at Venice, and 1/9 at Bevilacqua palace at Verona.

On modern buildings of the Dresden school, the entablature including frieze and architrave measures about 1/17 of the total height of the building, or about 1/30 to 1/40 omitting the frieze and architrave. Other schools of architecture employ b bolder cornices, those of the Dresden school have an elegant and refined effect, without appearing too small. Gnauth obtaened good proportions in two palaces at Stuttgart in employing 1/10 to 1/12 for the entablature or 1/25 to 1/27 for the cornice alone. No fixed rule of normal proportions exists for height of cornices, but only starting points are given at most, for these proportions depend on those of the entire building, its stories and absolute height, as well as the point of view. it must be left to artistic feeling to find the correct proportions in each case. The extreme distance possible from the obrever and the building is also decisive in regard to proportions and height of the cornice. Genoa is characteristic in this respect with its narrow streets and tall palaces, high string courses and cornices. The projection of the cornice is determined by its construction chiefly. If the projection and height are made equal (Fig. 388), making h = height, the area of the cross section is about 1/2 h ^{2} so far as it projects beyond the wall face; this section corresponds to a rectangle of h × 1/2 h. Hence the block of stone must extend at least half as far into the wall as its height, and the more the as the projection exceeds the height. From this are derived the following ground principles. 1, material is saved by small projection; 2, in case of greater projection the stone should be hollowed as much as possible; 3, the cost increases with increased projection and height.

If a larger entablature is composed of several blocks of stone, attention must be paid to an equilibrium of overhanging parts with those built in the wall, and it may happen that it projects that the entablature projects as far behind the wall face as in front, when all the brlocks are fastened together

by clamps (Fig. 389), or at least enough so that the area of the shaded portion in Fig. 390 exceeds the other part. From the entire discussion it results that a continuation of the w wall in form of an attic story is preferable, to bring the centre of gravity of the cornice as near as possible to the axis of the wall. Further that it is desirable to lighten the entablature as much as possible by the use of modillions, dentils and ornamented mouldings. But it is to be noted here, that the modillions must not be cut from the same block as the geison, but they must be in a separate one, since the geison would be too heavy and the purpose of the modillions would be lost. Thus the mutules and their drops in the Doric style are objectionable as being the contrary, and it would be better to treat the underside of the geison with sunk panels. Further the dentils by which cornices are made lighter and animated are useless if their projection is slight, and therefore are best omitted in string courses of small projection.

In its simplest form, a cornice now consists of three elements, the strongly projecting geison, the supporting lower members, and the crowning upper members (Fig. 391). The geison is hollowed on its underside to form a water drip.

If as in Greek architecture the crowning member or cyma also forms a gutter, this must be much higher than the facia and so becomes a dominating motive, and to not unnecessarily increase the weight, a steep and slightly projection is given to it (Fig. 392). But the facia predominates in most cases, and the crowning member is best wrought on the same block as the geison and not separately in case an actual gutter is used. In richer forms weaker members are inserted between the cyma and geison.

By our method of stonecutting, i.e., making all cut stones from rectangular blocks, it is absolutely necessary to retain the horizontal joint a f under the geison (Fig. 393). It it is desired to treat the underside of the geison with sunk panels, the drip should be short and bordered panels should be inserted between it and the supporting lower members (Fig. 394).

The readiest expedient for enriching and strengthening the cornice is the insertion of a second projection between the supporting lower members increasing them. (Fig. 394). This second projection is preferably formed by dentils (Fig. 394).

between it and the geison are placed modillions in still richer cornices, around which the upper mouldings of this course are broken. In the richest cornices a group of members is placed under this row of modillions, and even another projection with its upper and lower members.

A frieze and eventually an architrave is placed below the cornice whenever required by esthetic needs. The frieze may remain flat or may be decorated (Fig. 394 a), or it can be formed of a series of vertical modillions as in a fine example by Vignola, which permits a still greater projection of cornice

All modern cornices are merely variations of this motive, already fixed by the classic and Renaissance styles; the question therefore is whetheh one will adhere more or less closely to Grecian, Roman or Renaissance architecture. whether he will adhere strictly to the columnar orders or not, or the cornice shall be ornamented and in what manner.

The architrave may be made lower in facades, since it is completely built into the wall, than when used over a colonnade or portico, which require the stones to have a certain strength

δ. Interruptions of Cornices.

A peculiar conflict arises if the centre or end portions of a facade in three divisions are made higher. If the cornice of the lower part is carried across the entire facade, a main cornice will then be used as a string course, which is unseemly, or the higher portion must be made to project sufficiently, t that the cornice of the lower portionmay die against it (Fig. 395 a,b). It will then be best to strive to adjust this, so that a portion of the cornice of the lower part of the building may be changed to a string course for the higher portion (Fig. 395 e). Or the string course of the higher portion is broken around and unites with the cornice of the lower portion (395 c)

To let the cornice of the lower part simply abut against the projection of the higher part, as done in Greek architecture and by the advocates of that style in our era, is and remains a faulty expedient of an undeveloped art. The architecture should at least be so arranged, that at the height of the architrave of the lower portion a slightly projecting band extends around the higher part to preserve continuous lines and to properly connect the parts (Fig. 396).

If we follow the principles of Greek antiquity in such cases, we shall only too readily employ two different scales, which was usually happily avoided by the Renaissance style.

3. Stories not separated by horizontal Members.

Instead of separating the stories by string courses, it is sometimes customary to carry the masonry unbroken from the base to the cornice, dividing the wall by projecting pilasters or projections, thus forming it in vertical stripes; even columns extending from base to cornice are employed in this manner. A Although a powerful effect may be produced by this means, the arrangement containing an internal contradiction. It is always most natural to allow horizontal lines to dominate, and even when vertical projections of the wall are arranged in form of pilasters, etc., no reason exists for suppressing the horizontal members, which may either stop against the vertical projections or be broken around them. Even Gothic church architecture, which made vertical lines dominant, never suppressed horizontal divisions, but on the contrary, treated them the more boldly in the places where they were justifiable.

4. Galleries, Balconies, Verandahs, Bay Windows, Corbellings, etc.

α. Galleries, balconies and verandahs.

Halls, whether intended for church or secular purposes frequently have galleries on one or more sides. When they are of small breadth, they may be formed by corbelling out beams of stone, wood or iron, which support the architrave or floor, b but in order to appear strong, they require to be supported by consoles, corbels, etc. Galleries, several of which may be placed over each other, are either vaulted or not vaulted; are open to the interior of the hall and rest on arcades or colonnades. They have solid or perforated balustrades in front, and may be treated like a series of connected windows. These galleries become porticos, loggias and verandahs on the exterior of a building, porticos being understood to signify a long hall open at one side, a loggia being a living room open at least on two sides, and verandahs are similar structures of lightest construction. These rooms are intended for living in the open air, so as to enjoy the fresh air and fine views, may be arranged in houses as well as in public buildings. If covered, the

lighting of the room behind is impaired in case it is lighted by front windows. A construction as light as possible , slender supports and as many openings as convenient, are therefore desirable, and the entire character will be thus determined, which pleasantly contrasts with the more solid facade, that is broken or extended by the portico, etc.

β. Bay windows and balconies.

Bay windows and balconies are rooms outside a house constructed by corbelling out the walls, as usually defined. They may also be added to the walls of cities and fortifications, terraces of chateaus, towers, etc. They are always occupied rooms obtained by projections, are finished with balustrades and are supported by corbels, consoles, vaults, etc.

The ordinary balconyis generally a single stone slab supported by consoles or corbels, whose thickness is about the same as the depth of a string course, its edge being moulded like the latter. The thickness of this slab depends on the material, on the projection of the balcony, and on its loading by the p persons who may be on it. Its underside may be decorated by s sunk panels of any kind, provided that they do not materially weaken the slab. It may project considerably beyond the consoles. If all unnecessary weight of the balcony is avoided, open balustrades of wrought iron are preferable to solid ones of s stone or masonry; the wrought iron rods and ornaments, as in balustrades of stairs, must be placed so near together, that a child's head cannot pass through, so not exceeding 6.7 to 7.1 ins. The height of the balustrade should be scarcely less than 3 ft. The same is true of balustrades in general. Those of balconies and of galleries are constructed also of perforated slabs of stone let into angle posts and covered by caps. These caps may have profiles like those of window sills and should be at the same height.

Balustrades of perforated stone slabs are very pleasing in construction with ornaments of wrought iron. Since the Renaissance period, balustrades composed of short supports like vases have been and will remain in use. The intervals between them may be filled by ornaments of wrought iron, which produce a very good effect.

Evideytly the balustrades of bay windows of living rooms and of halls of all kinds must be solid. If it is desired to perf-

perforate them, a solid panel must be placed behind them. The bay windows have a pleasing effect in connection with the entrance door, giving rise to many peculiar arrangements. The bay angles of corner houses are places especially favorable for a angle bay windows. Hence they may differ greatly in form of p plan, be oblong, square, circular, etc.

5. Stairs.

We do not have to consider the construction of stairs and t their arrangement, but principally their forms. Accordingly in their arrangement, they are straight, i.e. with a straight course, and winding with a curved course. The steps may be supported by a string at one and or this may be omitted, or by small columns or piers forming a system of tracery. The balustrade and hand rail encloses the stairs on their open side; t the under sides of the landings influence the effect of the design in many cases, as well as the newels against which the hand rail usually stops.

α. Stairs with and without carriages.

If the steps lie on each other so as to be supported without a carriage, the ends and undersides of the steps may be decorated by sunk panels of varied forms. If strings are used, these may be simply inclined like the rise of the steps, or they may be formed in steps on their upper edges, or lastly steps may alternate with inclined parts. (Fig. 397).

These three arrangements will be more or less suitable according to the arrangement of the balustrade. A moulded upper edge and moulded underside of the string will have a pleasing effect. The string may also be so treated as to form a series of supports like consoles (Fig. 398).

B. Stairs on vaults.

Stairs are vaulted underneath in many cases. The most different kinds of vaults may thus be used. Stairs whose steps are built into the walls at each end give rise to a very pleasing arrangement by constructing an arch under each step, so t that the vault itself ascends in a stepped form. The same principle produces peculiar and pleasing forms in winding stairs, that are especially adapted to brick construction. One of the most pleasing kinds of stairs is that in which four straight flights run around a square opening; If the stairs and landings are then supported by groin vaults, these are alternately

inclined, producing very varied forms of ceilings.

One of the most beautiful motives for the treatment of stairs was a particular favorite in mediaval church architecture, and is that where the steps are supported by small columns. If these are changed into tracery, they lead to most varied forms, suitable for small stairs, especially those used in houses within the rooms themselves or in church architecture.

γ. Balustrades of Stairs.

These are of stone or of iron. If made of stone the hand rail is supported by balusters, though small columns are also favorites. Or perforated slabs are arranged, either decorated by free ornaments or formed of tracery in strictly geometrical p patterns. Balustrades of wrought iron are particularly suitable, which consist of vertical decorated bars or of free scroll work. Cast iron and bronze may also be used, though cast iron will seldom be employed for balusters on account of its brittleness and bronze is so expensive, that stone or wrought iron will be preferred. Cast zinc is very suitable for the interiors of buildings but requires to be painted or gilded on account of its unpleasant color. Evidently wooden balustrades would only be used for wooden stairs and may be composed of separate pieces, or be actual wood carvings. On the other hand, wrought iron balustrades are also suitable for wooden stairs.

δ. Angle newels of Stairs.

Against these abut the balustrades, the hand rails and the carriage, and they afford opportunity for the most varied treatment. Care must always be taken to have the parts just named join the newels in a natural way and properly. The newels are suited to receive a gas fixture, a vase of flowers, an ornamental figure, or one supporting a coat of arms, etc. Their f forms are treated in accordance with the particular case for which they are used, with their arrangement, and with the material of which they are constructed. They always require a p plinth and a cap, and in many cases a crowning ornament; the forms of the plinth and lap should harmonize with those of t the carriage and hand rail, with which they may or may not be connected.

ε. Landings.

Care must always be taken to secure a pleasing treatment of the landing slab, in case the underside is not concealed by v

vaults. Shallow sunk panels are suitable to not weaken the landing slab; the maximum depth to which they may be sunk depends on the thickness and clear span of the slab, and on the particular case in which it is used. If large numbers of men use the stairs in buildings at certain hours, as in schools, theatres, concert halls, etc., it may become dangerous to weaken the slabs Therefore one must always carefully consider in special cases, whether the panels may be deep or shallow, and this is also t true of balconies.

ζ. Winding Stairs.

The undersides of the steps or winding stairs are either left of rectangular section, or they are dressed off to a heliccidal surface, or a vault is constructed beneath them. In the first case are formed wedge shaped prisms, with moulded edges or with surfaces decorated by sunk panels. In the second case the heliccidal surface may be ornamented by sunk panels, mouldings or ornaments arranged with reference to a helical line, or lastly a combination of the two varieties may be employed. In case of a vault beneath winding stairs, it may be divided in radial compartments; or may be an ascending annular heliccidal vault. The last arrangement permist pretty modes of treatment in brick construction with the aid of ornamental bonds, which were particular favorites in the brick architecture of Holland.

If the newel of a winding stairs is solid, it should have a hand rail moulding (Fig. 399), which must be of such form as to be easily grasped, and it is therefore usually a round between two hollows. If there is no newel, but a central well opening, this should generally be enclosed by an ascending helical string, moulded or decorated, and which is wrought in the solid on the ends of the steps. In larger winding stairs, this should be supported by small columns, very fine examples of which are found in the stair tower of the castle of Meissen, and in the graceful winding stairs of the so-called Woman's House at Strasburg in Alsace.

Very grand winding stairs should have a stairway separate for servants instead of a newel, which may be lighted by windows, so that an opportunity is obtained for decorations the walls of winding stairs by niches, tracery and similar motives.

6. Towers.

Towers are either intended for stairs, for observation, or for bells. In all these cases they have an upper story essentially different from the lower stories; the upper landing of a stair tower is lighted by a window, as well as the entrance to the attic story, or to any other room. Towers for observation or of fortifications serve for temporary or permanent occupation. Bell towers contain a room for the bells. Church towers are either detached, ajoining, placed over the crossing, or are little towers on gables. The latter are also used in buildings that require signal bells, like hospitals, barracks etc.

x. Plans of Towers.

As for the plans of towers, they are either free on three sides and then projecting beyond the face of the building, or they are built in and are merely free on two sides or but one; the square plan is preferable. Towers may further be circular or polygonal, with three, four, five six or eight sides. The form of plan is decided by the purpose of the tower, and by the place at which it is connected to the building. Wholly detached towers are seldom placed near a building except when independent, like observation towers; but they may be arranged to be partially free, as they may be connected with the lower story of a building by an arch, above which they are separate.

Stair towers should always be attached at one side or stand in the angle of a building. They should generally be treated plainly, being subordinate parts of the building, should have small windows, and only their upper stories should be richly treated and have large windows. If they play a more important part, their openings should be more numerous, and they should be lighted by larger windows. In many cases a gallery supported by corbelling or other supports extends around them at the height of one or more landings. The string courses should be stepped corresponding to the stair inside, or they should be arranged horizontally and placed at the same heights as the stories and the window projections. One or the other arrangement is preferable according to the particular case.

B. Towers for Observation.

Such may be entirely free or may be attached, partly containing stairs, the uppermost part being furnished with gallery,

balcony and [illegible] expedients for facilitating observation. Church towers are frequently also for observation, especially when they serve as stations for fire watchmen. They then have a special story fitted as a dwelling for the watchman, where the watch is kept during the night. Such a story produces a special effect on the entire tower.

γ. Bell Towers.

These are essential requisites for churches. Their most important portion is a room for the bells, which must have as large or as many openings as possible, so that the sound of the bells may be heard at a great distance. Their character is also determined by their purposes. The towers of churches are usually intended for quite different purposes. For example, a tower may contain a vestibule in the ground story, an organ gallersy in the second, a room for the clock in the third, a room for bells in the fourth (bells and clock must never be in the same tower), and one for watchmen in the fifth. This would require a tower in five stories with different heights and differently treated. In contrast to the open story for bells, the other stories are to be as nearly closed as possible, unnecessary openings being avoided.

For churches with nave and transepts, the crossing affords opportunity for a large tower, that may be a bell tower, may light the crossing, or be for observation only. In these cases it may have as many and as large openings as possible. Its form of plan depends on its purpose in the entire design of the church, and what esthetic and material parts it plays.

Town halls should have a tower in many cases, whose lower rooms may contain archives and an open balcony, etc., while in its upper part may be a clock and bell for the hours, and a room for a fire watchman. The tower story of the tower is often at the same time the city jail. The form of the tower is varied according to circumstances, but being for secular purposes, all ecclesiastical character must always be avoided. The same is true of towers for observation, those of prisons, city gates, bridges, chateaus and fortresses. A fortress character is more suitable for these with decorations by battlements, bays, etc., to produce a picturesque effect.

δ. Roofs of Towers.

The most necessary factor in the treatment of the tower is

the roof; toowers may have wooden roofs, stone spires, or iron roofs; they may terminate with domical, pyramidal or conical forms. A crowning form may be produced by combining these forms.

The treatment of the roofs of towers is one of the most fruitful and welcome problems for the architect in all cases. The elements available for the purpose are:- 1, open galleries with columns; the so-called dwarf galleries; 2, dormer windows; 3, forms of gables; 4, placing masses at the angles; 5, several galleries above each other; 6, the roof itself, whether it be a dome, a hip or a conical roof; 7, corbelling out bay windows; balconies and galleries with balustrades; 8, gargoyles, finials of all kinds, weathercocks, crosses, and other ornaments for the apexes of towers. The most varied treatment results from the combination of these elements.

C. ROOFS.

Roofs are generally of decided importance in the external effect of buildings and structures, since they materially aid in forming the visible outlines. Therefore sound artistic feeling led the Greeks, no less than the mediaeval masters, to lay the greatest stress on the treatment of the roof. Less attention was paid by Renaissance masters to the forms of roofs, with the exception of the domed roofs of churches, and thus in our time this tendency of the Renaissance is aimed at by many architects, to allow the roof to have the least possible part in the effect of the building, by concealing it behind an attic, or by making it so flat, that it cannot be seen. There is missed a rational development of the roof less in Italy; where wood is not abundant there and snow is hardly seen, flat roofs are the only appropriate way, and are actually necessary for sake of economy. It is otherwise in our North, rich in both wood and snow. The entire northern nature requires the perpendicular lines of our buildings to be emphasized by the roofs; here rich in forests, the cities would seem to have been burned, if the buildings did not have their powerfully effective roofs, with all their accessories of dormers, chimneys, etc. Therefore care must be taken, that the roofs are artistically treated to enhance the entire architecture, not to disturb it. It should not appear as if the architect could not design anything above the main cornice. Magnificent buildings like the former court theatre in Dresden, require something more than a

formless and colossal roof with lightning rods. Among its animated surroundings with the outlines of the court church and of the palace with its tower, the heavy mass of the former theatre appeared very badly. Among the many noble buildings, which occupy the Ring street in Vienna, the Town Hall with its well developed roofs appears far more advantageously than the new Museums, that look as if they had been burned.

We shall now treat in detail the following.

1. Batter of walls. 2. Forms of roofs.
3. Roof covering. 4. Dormer windows.
5. Ridge towers. 6. Chimneys.
7. Decorations of roofs. 8. Gables and pediments.

1. Batter of walls.

Enclosing walls are properly battered, that rain water may flow off on that side where it would be least injurious, that would usually be the exterior toward the street, where means of removing the water are usually provided. In this case it is proper to add a drip to the battering side of the wall. The same is true for battlements.

If it is required to prevent all persons from passing over the wall, a cresting or iron lattice will be suitable, and may be made of very pleasing form. It will also sometimes be necessary to give the top of the wall a richer form, so as to make separate parts of different heights, and to animate the wall by means of windows, vases of flowers, as well as on iron lattices and similar expedients.

2. Forms of roofs.

The principal forms of roofs are the shed roof, hip roof, gable roof, and the pyramidal hip roof. Composite forms may be used as required. Thus a gable roof may be hipped at both ends, or a gable or hip roof may join another gable or hip roof, a favorite for the roofs of towers. The inclination of roofs will frequently vary to produce better effects, for eaxmple, so that the ends of a hip roof may be steeper than its sides.

At the present time it often becomes necessary to employ the mansard roofl and for the angle pavilions of public buildings, the curved mansard. These forms of roofs are entirely appropriate where resulting from needs.In the same way for sake of economy, it may frequently become necessary to lessen the height

of the roof by placing a deck above a straight roof.

On esthetic grounds, roofs composed of curved surfaces should also be employed, as for pavilions and conservatories.

In all cases the proportions and forms of roofs are to be chosen to add to the effect of the building. If a space for passage is arranged above the main cornice with balustrades, these should never exceed 3.28 to 3.61 ft. in height; high balustrades make the building appear low and low ones high. The balustrades can scarcely be lower than 3 ft., since their purpose would not then be fulfilled. If these balustrades are arranged in connection with pedestals supporting statues, these must be designed to produce a suitable sky line.

3. Roof Covering.

Care must be taken that the roof covering not only fulfils its purpose, but also has a pleasing effect. Even thatched roofs of straw may be made pleasing by the way in which the bundles of straw are fastened. The roof covering of rural buildings generally has a picturesque effect from accidental circumstances of all kinds; sometimes composed of stone slabs of irregular form, as in places where plates of porphyry or of Jura limestone are used; sometimes of shingles held down by stones. Moss and all kinds of plants which grow on roofs frequently appear very picturesque, although this growth is n not beneficial to the woodwork of the roof. By cutting the lower ends of shingles are formed many kinds of patterns on shingle roofs, but care is necessary that the shingles be made of such forms, that water may be kept as far from the joints as possible.

Tile roofs take different forms according to the mode of laying, single, double or crown, also when the vertical joints are continuous or alternate, whether the tiles are set in bond, as in the last case. The forms of tile roofs further depend on the form of the lower ends of the tiles, as well as whether a any tiles of special patterns are used.

The ridge and eaves of the roof always require special precautions to prevent entrance of rain water, and to properly carry it off. These places also demand ornamentation for any covering of the roof. Hence borders of differently colored tiles should be arranged along the upper and lower edges of tile roofs in patterns with ridge tiles of special shapes, or suitable

finials at the apex of the roof, that are to be treated as free ending forms.(Tectonics, p. 195 et seq).

In case of slate roofs, the most picturesque effect is obtained by the use of the old so-called German method of laying. By the use of slates cut to special forms are produced the most varied patterns, which may further be heightened by employing slates of different colors. Borders along the ridge and eaves and bands around dormers are always decorations peculiarly suited to roof surfaces. The ridges of slate roofs are most properly covered with metal, and crestings of perforated plates, of hammered work, or of cast lead and zinc or wrought iron, are always proper, as well as finials of these metals.

4. Dormer Windows.

In many cases a kind of story is arranged in the roof, especially in mansard roofs, which is lighted by large windows. These may be very richly and ornamentally treated. They generally consist of an architrave between pilasters, which support an entablature and pediment, and its base can be extended by volutes at each side (Fig. 400 a, b, c, d; Fig. 401, a, b, c). They may be then properly grouped with the windows of the upper story.

Large dormer windows are sometimes required by the need of hoisting weights by a crane when in a warehouse. They then have a strongly projecting roof in which the carne is fixed, and are closed by doors. These are decorated by wrought iron bands. Dormer windows usually serve for lighting and ventilating an attic; according to the importance or subordination of the part played by them, they may be decorated by ornamental gable roofs or left plain. Wooden gable roof of church towers are often decorative expedients of prime importance, and they may be connected together to facilitate fastening the ropes require in slaters' work. Dormer windows of houses and of public buildings may sometimes be circular, semicircular or elliptical, or generally may be of the most diverse forms. They should have an architrave and some form of cresting, frequently made of sheet zinc. Dormer and roof windows always add much to the decorative effect of a building.

5. Chimneys.

In a fully developed architectural style, one must not forget to make the chimneys of pleasing form, and to arrange them so

so that the effect of the building may not be injured. They should then have bases with caps at their tops for the discharge of smoke. The form of this cap always depends on its special mode of construction. It is proper to give the chimney a twisted shap as well as to combine several flues in a group, covering the whole with a roof of sheet metal to keep out rain. This roof may be decorated by small gables or have the form of a crown.

6. Decorations of Roofs.

Among the decorations of roofs, the cresting is here specially considered, and it may be executed in wrought iron, cast z zinc or hammered sheet copper, and it is generally arranged as a cresting on the ridge of the roof; then the finials are free ending forms of the same materials, in the shape of sprays of flowers and leaves, decorated by weathercocks, crosses, animals and all sorts of forms, ornamenting the angles of roofs and especially the towers. Few general principles may be given for crestings and finials, since the greatest freedom is admissible in their treatment. They produce the most pleasing effect if they are partly painted black, partly gilded, and by their open appearance afford the most beneficial contrast to the massive character of the roof surfaces.

7. Pediment or Gable.

These form the end surfaces of gable roofs, and are either closed as in antique temples, then being decorated by sculptures or opened by windows of circular or other forms, which light the interior of the roof; they may be closed by an open stairway, so that one long side of the building is connected with the other as in some Romanesque churches. In houses and palaces, the attic frequentls contains one or more rooms and then has windows; these are sometimes decorated in the richest manner and are divided in several stories. Their outlines consist of the two inclined lines with the same slope as the roof, or these are stepped to appear as battlements; from the latter were derived the richly decorated gables of the German Renaissance, by the aid of ornamenta, accessories of all kinds.

The most natural mode of decoration is to make the two ends and the centre most prominent by acroterias and sculptures; all modes of loading the ends heighten the apparent stability, although seldom really increasing it, and the acroteria at the

centre satisfies an esthetic need. In very high gables, as in those of churches, these free ending forms require a proportionate height; gable crosses, finials, figures and similar motives may then be employed. The gable is covered by a cornice, that may be ornamented by crockets in some cases, like those of the Gothic style, or may be resolved into free and fanciful forms as in the German Renaissance. Both are justifiable for buildings of earnest and dignified appearance, churches, museums, opera houses, etc.; the second for those intended to have a character of greater magnificence, for chateaus, theatres, comic operas etc.

B. STONE CONSTRUCTION.

This is the most monumental and worthy expression of architecture, and at the same time is the most expensive mode of construction. The true historical development of architecture was carried out in stone construction; those in brick and wood only approximated **it** in other materials, to the forms and motives already existing in stone construction. It is indeed true that in different places, stone construction was first developed from wood construction, borrowing from thence a part of its forms, like those of the entablature, columns and gable roof; but the further development of these and other elements first occurred in stone construction, as well as the determination of esthetic proportions. The resistance of stone to crushing and transverse breaking prescribed the limits within which stonework could be employed; resistance to tension almost never comes in consideration, or only as it may occur in a beam under transverse stress. The elements of stone construction are always monolithic beams of stone, posts, slabs, ashlars and voussoirs of arches and vaults. All architectural construction is arranged with reference to these. Although a greater firmness is given to stonework by the use of mortar, it must itself be so arranged, that the different parts of the structure are in a state of stable equilibrium. It is always characteristic of stone construction, that the elements of its structure always remain within certain limits, depending on the thickness of the layers of stone in the quarry, and that considerable projection is possible for cornices, and further, that the mode of cutting also aids the effect.

With reference to this, see Tectonics, p. 117, etc.

Further, the use of different qualities of stone may strongly characterize stone construction. The harder stones should then be employed for the structural parts and the softer for the mass of the walls. In this way, the water tables, string courses and cornices, architraves of openings in walls, supports and the remaining cut stone work will be sharply distinguished from the masonry proper. This is also true of walls plastered externally, or if stones of equal hardness and strength but of different colors, for example red and white sandstones are employed in a structure. The rarer kind of stone should then be used for the architectural details proper, and the more common for the masonry. This further depends on the ease of working the stone or on the texture of the material. If two kinds of stone are equally hard, like red and white s sandstones, one should decide in accordance with the character of the building which should predominate. Red sandstone used in mass gives the building an earnest and gloomy character; which has a cheerful and brighter one. The darker stone requires coarser forms than the lighter one. Tectonics, p. 182.

I. BRICK CONSTRUCTION.

In regard to the treatment of form in this construction, everything necessary has already been said in the Chapter of Tectonics on Bricks, p. 134 etc. In general and as a whole, the character of brick construction is determined by the small dimensions of the elements, by the intimate connection of the mass, and by the slight projection of string courses and cornices. It therefore always produces works that are massive, have small members and relatively low relief. Two styles have been developed in bric construction, the northern mediaeval brick architecture of the low northern plains, to which are allied the south Bavarian, lower Bavarian and Dutch, and the brick a architecture of upper Italy. The first style may be called brick architecture with moulded bricks, the second is that employing terra cotta. The northern style scarcely used terra cotta, which was a great favorite in that of upper Italy. Both styles lead to peculiar forms and both may be combined, or rather are already combined mostly in the brick architecture of upper Italy, since this style used both moulded bricks and terra cotta.

the difference between moulded bricks and terra cotta consists in this, that the latter is modeled, cast or pressed in moulds, and therefore admits of plate forms, such as parts of friezes, and freely sculptured ornaments, while moulded bricks are properly only profiled bricks, so that the first style renounces nearly all ornamental and sculptured ornamentation. On the other hand, the first style employs glazed and colored bricks, rarely ornamental blocks carved from sundried clay and burned.

However pleasing the works created by the northern mediaeval and the Lombard or Sienese brick architecture, without improved transportation a pure brick architecture excluding all stone will now be advisable only in some localities. But where cut stone may readily be obtained, it will usually be preferred to bricks, these being only used for the masonry.

K. MIXED STONE AND BRICK MASONRY.

In countries where brick is the ordinary building material and where sufficient cut stone may be obtained for the principal architectural details, a mixed stone and brick construction will be employed, like that found generally in the Netherlands, and there developed in a wholly specific way. At least there all the strong courses and cornices are made of cut stone, and blocks of stone are built in at the openings, wherever iron anchors are to be fixed for the wooden doors or window frames.

In a more developed form of this mixed construction, the brickwork is entirely limited to the masonry or wall, and the jambs of doors and windows as well as all other structural t parts are made of cut stone. On the other hand, pilasters for strengthening the wall may be of brick on account of the stronger bond, while their capitals and bases are of cut stone. In case of isolated piers, it is best to interrupt the brickwork at regular intervals by cut bond stones to give greater strength.

The mixed brick and stone architecture of many Dutch buildings of the middle ages and the Renaissance is really refined, and in it is a certain intention of producing a special effect by the contrast of colors of white sandstone and deep red bricks. No opportunity is lost for decorating springing and key stones, or for interrupting brick masonry by courses of stone placed at the same height as window sills or transoms (Fig. 402), so

that the brick masonry forms closed panels. These expedients give the mixed stone and brick architecture of Holland its peculiar stamp, and they form the readiest and simplest general means of obtaining a characteristic effect with small means, especially in buildings intended merely for utility, as in rural structures.

WOOD CONSTRUCTION.

Wooden houses are either built of logs or are half timbered. Compare what has been said of wooden walls under A, 4, 5, and also in the Chapter of Tectonics on Woods, p. 139.

Since in wood construction not only the resistance of the s structure to compression and transverse stress, but also to t tension is exerted, elementary structural forms result entirely different from those used in stone construction. Horizontal beams subject to transverse stress are beams, sills, purlins and straining beams. Vertical supports are posts, inclined ones being struts and braces, all subject to compression. Horizontal timbers in tension are tiebeams, and vertical ones are king or queen posts. For the forms of these structural elements, reference is made to the Chapter of Tectonics on symbolic forms, p. 122. The most fully developed wooden architecture with which we are acquainted is that represented by Swiss and Tyrolese houses, formerly mostly built of logs, lately with a timber frame lined inside. The strongly projecting gable roof, open galleries, low stories with numerous windows, lend to these wooden houses their characteristic appearance, that varies in the most different ways in each separate structure by means of carvings of all kinds, due to the abundance of wood in Alpine countries.

The remaining wooden architecture of Germany chiefly uses half timber construction, the interspaces being filled with brickwork; a projection of each story beyond that next below, and the steep gable roofs, characterize these houses, which are best adapted to the North. These half timber buildings with panles of brickwork, either plain or plastered, acquire a peculiarly pleasing appearance when the decorative brick bonds are employed.

M. MIXED WOOD AND STONE CONSTRUCTION.

Whatever may be said here was stated in general in relation

to the half timber work just mentioned. In many cases the basement story has a plain wall, especially if the upper story is half timbered. The extennal appearance of the building then depends on the materials and mode of construction used, as well as on the painting, sgraffito, ornaments in wrought iron, overlays of tiles, etc. Evidently neither pure wooden architecture nor mixed construction in stone and wood are suitable for monumental buildings, but both are better adapted to country dwellings, modest city houses or rural structures, etc.

This mixed style is well suited for small railway stations, foresters' houses, country inns, all the structures attached to the drinking room at baths and spas, and a peculiar character should be given to these to correspond to local conditions. This mixed style in purely wooden architecture will likewise be employed for temporary structures, for festivals and in general for those satisfying temporary purposes, after which they are to be removed.

N. METAL CONSTRUCTION.

In this only city buildings of wrought or cast iron require consideration. On account of the cost of bronze it was hardly used except in the classic period, and then but exceptionally as a special structural material. On the contrary, iron plays an important part in modern architectural construction.

The most extensive use of iron occurs in railway stations, buildings for international exhibitions, bridges and roof trusses. In accordance with the resistance of iron, all structures of it should have a character of lightness; compression is chiefly resisted by columns and struts of cast or wrought iron, transverse stress by iron girders and beams, tension by wrought bars or rods. The walls and roofs are mostly composed of thin sheets, when not built of masonry or wood in combination with iron, or even of glass. The general character of lightness possessed by iron buildings results from an endeavor for economy of material and labor, which requires each part to have the smallest dimensions possible. Therefore the stronger the structure, the less attention should be paid to its external artistic appearance, and it should be left to produce its own effect. In case of small structures, little pavilions, garden houses, etc., or railway stations, care must be taken

to decorate parts in cast iron and also to use wrought iron ornaments of all kinds. The same is true for fences, latticed gates, monuments, canopies over wells and similar objects. Perforated and hollow forms are suitable for cast iron, thin plates, bars and rods for wrought iron. General laws stated on p. 150, 154 and 164 of Tectonics are valid for iron and its uses.

O- MIXED IRON, STONE AND WOOD CONSTRUCTION.

In many cases a structure may be partly of stone, wood and iron; thus very large rooms have walls of masonry, the roof is of iron, and wood is used to receive the covering material. E Each material is used in such structures and the massive masonry pleasingly contrasts with the light and graceful forms of the ironwork. For example, massive stone bridge portals have a better effect than if made of cast iron, since casting must avoid a massive character; hence buildings for exhibitions, conservatories and similar structures are more pleasing, if partly of masonry, than if entirely made of glass and iron.

F. ARRANGEMENT OF PLAN.

Every arrangement of the plan results from division or addition, a given area being either divided into parts, or such p parts are arranged together.

A series of rooms are placed next the facade of a house, between two adjacent dwellings, and the remaining rooms adjoin the former. In a detached house, a villa, we commence with the largest rooms, drawing or living room, and the others are placed with reference to them. In the first case, the plan is made from front to rear of the building; in the second the interior is first grouped and then the exterior is arranged. If the house occupies a corner, two series of rooms are placed along its fronts, either leaving the principal room at the angle, or the corner is divided in smaller rooms, as may best accord with the requirements. A series of principal rooms should always extend along the principal facades of public buildings, unless the s structure is to be treated as a large hall, when the others are to be grouped around the hall. A corridor is often placed behind this series of chief rooms by which the rooms are made accessible. Therefore in public buildings the arrangement will progress from front to rear, but in hall buildings comprising theatres and churches, it will be from interior to exterior.

In order to make the best use of the site, the plan is always to be arranged, so that the corridors may occupy as little area as possible; but in many buildings like schools, the corridors not only serve for access to the rooms, but are also occupied by pupils in intervals between classes, as well as for reception of cases containing books, models, collections, etc.; they then assume a greater importance, which has an influence on t the plan. Space is always lost by vestibules, stairs, passages, etc., therefore one should arrange to make this loss as little as possible, and in very large public buildings, the loss of time must be considered, resulting from the connection of the different wings of the building by corridors, courts etc. Hence one should arrange near each other rooms properly belonging together, and to make their connection more direct by means of private stairs, corridors, etc. He should further try to make vestibules, corridors and courts as useful as possible, to serve for temporary occupancy by men, therefore arranging light courts with glass roofs, galleries of all kinds and loggias as may be required. This comprises the things of most importance that may be said of arrangement of plans.

6. SECTIONS OF BUILDINGS.

If heights of stories are fixed, the cross sections of buildings are controlled by the arrangement of the plans. The essential part of modern architecture relation to the section is, that only in exceptional cases resulting from the form of the site or from special purposes, is any story not arranged throughout on the same level, as the case in so many mediaeval buildings. Yet in exceptional cases, when peculiar arrangements make it necessary, some halls are made lower or higher than a story, thus extending either below or above it. When the conditions of the site are peculiar, as in mountain cities or castles, the accidental location of a site usually produces very peculiar arrangements of stories, where one must strive to make the best use of these conditions of the ground. Thus it may w well become necessary to abandon all rules and take into account the special cases. But one should be careful to place as many rooms as possible on the same level, and to retain the heights of stories decided upon.

8. FACADES AND COURT FACADES.

B. FACADES AND COURT FACADES.

The facade is esssentially derived from the plan and the section. The openings for doors and windows, porticos, loggias, towers, etc., principally determine the arrangement of the facade, the purpose and importance of the building, and the detail forms of the facade. Characterization requires not only that the exterior is the result of the interior, but that it may c correspond in every respect to the destined purpose of the structure. Therefore the choice of building materials and structural forms must be in strict accord with this determination.

Facades of courts are generally of subordinate character; yet in many cases the courts are developed into magnificent architectural works. The courts may be decorated by galleries, loggias, stairs and stair towers, bay windows and balconies, niches, water works and fountains, in brief, by any means of decoration. But it is to be remembered that a court must appear w well from the most distant point of view possible, and that according to whether the court encloses a garden or affords a fine view, its arrangement must be such as to utilize these advantages as fully as possible.

S. KINDS OF BUILDINGS.

In describing the kinds of buildings, we shall here follow the order employed in Baukunde des Architekten, Vol. II.

1. Agricultural Buildings.

These are to be regarded as being equivalent to a capital paying no interest. They must therefore be constructed as economically as possible, using the local and cheapest materials and structural methods. Hence their character is determined by plainness, neat appearance, and by the decoration of their natural surroundings, or by cultivated vegetation.

Their arrangement and grouping varies in accordance with their special conditions. If they are connected with peasants' cottages and farmhouses, the local character will decide their external appearance. But if they are to be considered as dependencies of the estates of noblemen, a greater expenditure in their erection will be appropriate according to the means of the owner; then in case of the existence of a prevailing rural type, they assume a more civilized character, so to speak; still it must always be avoided to permit them to closely approach the appearance of city buildings; they should remain rural structures.

Even in cities, agricultural buildings attached to the seats of noblemen, castles and palaces, should not exceed a certain modesty in their external appearance. This limit of permissible type and propriety will be fixed by the means of the owner, and the instinctive feeling of the architect.

As for these, so for all kinds of manufactories in general is suited a plain and unimportant character. Like the workmen in working clothes, all such structures should be modest in appearance. All expenditures beyond absolute necessity and an appearance of neatness is best avoided, the money being better if expended for the benefit of the workmen.

Yet designs for factories, by special requirements and conditions, afford opportunity for employing peculiar though simple architectural forms, and require a careful choice of them on account of their modest character, so that it is easy to recognize the intention to make these buildings pleasing at a moderate cost.

Country seats of noblemen not having the rank of villas, but containing both the dwelling and the farm buildings of the owner, should be treated as plainly as possible, so that all possible capital may be placed in the business itself. They usually contain in a higher ground story the living rooms and farm buildings, in a lower upper story being the bedrooms and the rooms for strangers. Solid construction and appearance, as well as simplicity are the chief requirements of this class of buildings. Pleasant surroundings by gardens and parks are the chief means of decoration worthy of endeavor.

Buildings for the forestry service are similar to those for agricultural purposes, and are subject to similar requirements in relation to external appearance. A rural character is advisable for these also, and an adaptation to local conditions, so all is to be avoided, that might give them a cityfied look.

2. City Houses.

These are separate dwellings for single families, whether for workmen, villas or palaces; or they are houses for rental and containing one or more flats in each story. They are further detached or are built in blocks, i.e., free on all sides, or are in rows and then are free on two or three sides only. The degree of external appearance and decoration depends on their

importance and size. Solid construction should first be required, if the greatest propriety is to be exerted, and all imitations of building materials are therefore excluded, all structural parts being of stone or brick, using plaster only in the interiors. A house should not appear more than it is. If the occupier can afford to rent an entire building, he can also afford a solid style of architecture; should he possess les means, he must then decide to live without decoration. If the house is for rental, the tenant must pay for the decoration in his rent, and thus pays for things that make him no return. This ground law of solid construction would materially simplify our entire city architecture, if carried out to its extreme results, which would be a great gain. For it would first compel us to economize materials, and secondly would cause us to learn to exercise the greatest economy in the use of our artistic expedients, without which economy is impossible a sound architectural style. Not richness is first to be fonsidered in a house, but a refined appearance suited to the rank of the occupant. This refined appearance first requires solidity, without which there can be no real magnificence. Everything not genuine or that is imitative lessens this refinement.

The plan of a house first depends on the means to be expended, especially on whether all rooms are to be on the ground floor, or are to be divided among several stories. A house becomes cheaper, the smaller the area of ground covered by it, and the narrower its facade. It will therefore usually be preferable to occupy more than a single story in practice, if the house contains a single dwelling. If the house is in a block, it will be cheapest if narrow. In large cities where ground is very dear, each house becomes high and narrow, containing three or four stories, each with at least one flat. The entire external appearance is then arranged in accordance therewith. Even in houses for rental, occupied by several families, it is usual in many cases for each to live in two stories, for example at Amsterdam. Such a house would then require four stories for two families. The external decoration of the house is always arranged in accordance with the plan; therefore effectively grouped plans should be avoided, unless the owner has the means for also effectively treating the building.

A principal requirement for villas is to obtain as large an area of wall surface as possible for the reception of furniture, consequently not putting in more windows than are necessary to light the rooms. Hence in many cases an external wall is arranged without windows. Esthetic needs may require this wall to be decorated to not appear monotonous, but one should not resort to the cheap and senseless expedient of arranging blind windows. Picturesquely grouped villa plans with projections and recessions chiefly result from the general location, whether they are connected with gardens, look out on fine views, and further according to the site, which usually demands a picturesque grouping. The building may then be treated by means of loggias, bay windows, stair towers, verandahs, and like means.

If houses for rental are detached, to reduce the area of ground occupied and the width of facade as much as possible without lessening the requirements of the rooms, an approximately square plan will be preferable, since the square has the smallest perimeter for its area, except the circle. These plans usually result from rectangular sites, if the facades are limited to a minimum in proportion to the area of ground covered, for in case of an equilateral triangle its perimeter is more.

The richer and more extended are the plans of villas and of palaces, the more refined should be their external appearance; if it is desired to reduce their cost to a minimum and to build as quickly as possible, making the building habitable in the least time, one returns to the old Florentine type with rustic masonry and the simplest arched windows. If it be desired to adhere to the ground law of solidity with the greatest economy, as in the great houses for rental, in modern cities one resorts to the type of the Roman palace with details of stone and walls plastered externally. These are the limits within which the designs for the largest palaces must lie, while these palaces are for private persons. Princely, royal and imperial palaces, as well as that of the president of a republic, governor, etc., very far surpass these limits, since their chateaus and palaces are intended for their successors, while private persons usually build for themselves and their families. There are naturally many other factors that influence the character of palaces, but besides the building materials employed and the magnitude of

the palace, the principal one is the time allowed for their c completion, which can only be reduced within certain limits. Hence with smaller dimensions a relatively richer treatment of palace architecture becomes possible.

The principal difference between palaces and public buildings is in their character as dwellings, chiefly indicated by the treatment of their windows.

Evidently the most varied modes of treating houses are possible in other respects, according to the reouirements in special cases. These will always produce certain results according to the way in which they are combined. Thus in different countries for satisfying different human needs, the expedients of the architecture of houses and palaces take different characters. The modes of life of different races, the materials at their disposal, the rank attained by the architectural development, the climatic conditions, the abundance of a circulating medium, material wealth, and other factors , will decide the treatment of dwellings. Even the frequency of natural occurrences, earthquakes and inundations, storms and tempests, s snow and rain, etc., will influence the character of houses, as well as the local situation, conditions of the site, and t the need of greater or lesser durability.

The "tooth of time" then does the rest necessary to change the appearance of the building, and to change the splendor of newness for the venerable appearance of the historical.

3. Churches.

In churches all should be avoided which recalls secular architecture. They are buildings for the exercise of Christian worship, and we need only to consider the evangelical and Catholic confessions. The evangelical church only recognizes parish churches in cities and villages, and chapels like those found in hospitals, prisons, etc.

The Catholic church requires :- a, bishop's churches, cathedrals or minsters; b, collegiate and abbey churches; c, parish churches; d, pilgrimage churches; e, votive, cemetery chapels, mausoleums.

The arrangement of the church must always be suited to the average number of attendants, which by investigation amounts to 55 per cent of the population, of which 4/5 are adults and

1/5 children in round numbers; afterwards to the special needs of the church which are:- a, the choir for the clergy; b, the nave for the audience; c, the sacristy; d, the tower; e, the necessary vestibule, baptistern, rooms for instruction, for records, and for servants of all kinds.

The plan of the church should either be arranged about a centre, be oblong, or according to the Greek cross of equal arms, according to the Latin cross of unequal arms; the plan may be modified in most diverse ways by use of transepts, vestibules, additions to choir, chapels, as well as by location of the towers, and finally by the forms of these elements. From its plan with one or more aisles and the combination of plan and section, producing a hall church with aisles of equal height, a chuber with higher middle aisle, or finally a basilican design lighted by windows high up in the side walls, results the external masses of the building, modified in some cases by the towers, sacristies, chapels, galleries and triforiums, by treatment of the roofs and of the rather subordinate gables, dormers and ridge turrets. The interior will vary with the construction of the ceiling and the supports, also with the distribution of t the light and the treatment of the windows.

Under all circumstances the most dignified and monumental effect conceivable in the case is to be striven for, in both interior and exterior of the building. Therefore external plastering of walls is only advisable in case of absolute necessity. If strict economy is needed, a building arranged on the central plan will require less enclosing wall for equal area than a cross shaped plan. Yet in the most favorable case of a circular plan, the length of wall would be only about 1/10 less than that for a square plan of equal area. Hence the gain would not be great. From its considerable volume, a church always requires a certain height corresponding to its area, especially if vaulted, and this chiefly depends on the span. In this way by its considerable extent, the church always predominates over other buildings, and the grandeur of the masses always demands a certain grandeur in the architectural forms, which must be chosen according to each special case. To go into details of church architecture belongs to the developed theory of building, which it is not proposed to treat here. It is now sufficient

to note a few essential points, that determine the specific character of churches as differing from other buildings. The most essential portion is the treatment of church towers and roofs on which a special value is laid. The richeness of the treatment should accord with the importance of the church, and depends on quality of materials, variety of architectural forms, as well as the ornaments and statuary. Except in rare cases, a certain limit in decoration is not easily exceeded at this time; the era of great cathedrals lies behind us, hence one must strive to produce the desired effect by the power and originality of the architectural motives, making the details noble and dignified, but renouncing all elaboration in details.

4. Cemeteries.

Modern cemeteries are either parks or architecturally treated burial places surrounded by porticos with some necessary buildings at the principal entrance. Since they are most properly at some distance from cities and on elevations, their landscape surroundings usually aid and increase the solemn gravity required. The burial places are common trenches, separate graves, tombs and family tombs. The great burial field serves for the first use, while the tombs are arranged in the surrounding porticos. On account of the great extent of cemeteries and the low height of the enclosing buildings, it is desirable for esthetic reasons to break up and dignify the long porticos by structures like chapels at their centres and angles. It is very suitable to arrange the larger monuments and mausoleums to form streets of tombs after the classic method. Porches at the entrances of the porticos, a memorial hall, a chapel and buildings of all kinds near the principal entrance for diverse purposes and adapted to needs varying with local conditions, serve to decorate these cemeteries. It is always necessary to express the gravity and solemnity if their purpose in their architectural arrangement and decoration, and all must be avoided belonging to secular architecture. Structures connected with cemeteries are as follows:- portals, residence of superintendent, houses for hearses, chapel, offices for officials and physicians, dwellings for employees, foremen, excavators and gardeners, shops for sale of flowers, mortuary with dissecting room, crematory, wells, water closets, gardens, nurseries and conserva-

conservatories. To combine all necessary buildings in pleasing groups is the problem of the architect.

5. Synagogues.

These serve for Jewish worship; hence everything is to be a avoided in them, that recalls the Christian church, and especially the cross plan. All essential elements of the synagogue will be named; vestibule, room for men, sanctuary, rooms for rabbi and chorister, women's room, stairways, wardrobes, hall for deputies and president, water closets and cellar. The spacious vestibule forms the principal entrance and gives access to the stairs leading to galleries for the women, and at the same time forms the chief part of the facade; this vestibule may remain entirely open. From it is entered the room for the men with seats extending from east to west. The sanctuary is a kind of choir requiring special arrangementr for receiving the sacred writings in a fireproof vault, and requires artistic decoration. Rooms for the rabbi and chorister are toward the east. Women should always occupy galleries, that require two platform stairs at the west and the east in case of sittings for more than 600 women. For the given needs and the requirements of divine worship, the centrally arranged plan is m most suitable, or the ordinary basilican; the first being preferable by its overhead lighting, that can be obtained by a dome. Oppler rejects the Moorish style for the architectural treatment of the synagogue and recommends the prevailing style of the locality. Towers are only to be used for stairways. Representations of the human figure are generally excluded from the synagogue, only plant and geometrical forms being allowed with an inscribed frieze, and the crowning symbols of the tables of the law and the shield of David, the hexagram.

Strict regulations for construction of synagogues require t them to be entirely built of cut stone and brick, excepting c cast iron in the interior and stone columns for supportiong the galleries. Oppler also recommends monumental ceilings, i.e., vaults of all kinds as well as wooden ceilings with visible trusses, and monumental constructions for the roof with the use of copper as a covering material.

6. Jewish cemeteries.

These should be enclosed by monumental walls and be divided by rows of trees into sections containg rows of graves, the

intersections of the avenues being decorated by fountains. The inner sides of the enclosing walls are occupied by family tombs.
The entrance to the cemetery, with all side doors for persons on foot, opens into a court, whose longer side is occupied by the hall for religious services, the buildings on the other s sides serving for the guards of the cemetery and for religious purposes. These comprise a room for prayers extending from west to east, as well as a room for washing the bodies. The room for prayers must open directly on the court. The hall must also extend from west to east and requires wide doorways in the middle of its longer sides, through which the coffin is carried, and large windows extending down as low as possible, since the rabbis conduct the service from the outside, not being allowed to enter the hall. All these buildings must have a monumental and dignified appearance. (Baukunde des Architekten. II. p. 270, 284, et seq.).

7. School buildings.

α. Primary schools.

Small school houses for primary and village schools must be solidly and simply constructed, monumentally treated when this can be done. It is always proper to so arrange the class rooms to admit the light only on the left hand side. The windows should extend up near the ceiling and be as numerous as possibll, to admit abundant light to the class room. This determines the character of the building, that must contain many windows, these being grouped. A large hall is generally placed in the upper story and a gymnasium in the basement, if not in a separate structure. These parts should be externally distinguished from the others. Drawing rooms should be long and narrow with north light. Since school rooms differ much in form and location, there are usually projections and recessions in the building, which thereby obtains an animated appearance.

β. Higher schools.

For higher schools, gymnasia, real schools and higher girl's schools, a richer external appearance is desirable, suited to the means available, dimensions of the building and the higher work of the school. Solid construction is also here the first requirement, the exterior of the school should be as substantial as the instruction, there given. The hall requires larger

dimensions and therefore leads to a considerable enlargement in plan, and it should be artistically treated in the richest manner.

γ. High schools. (Secondary or professional).

Universities and polytechnic schools, academies of art and similar higher schools require the relatively highest decoration of the exterior according to their importance as institutions of learning. These buildings contain college lecture and class rooms, the great hall, roofs for officers and professors, museums, laboratories and studies. In recent times such buildings have been arranged as a connected series of buildings, so that the principal structure, besides the great hall and the offices, only contains lecture rooms and eventually the museums. All laboratories and special departments are placed in separate buildings. The hall and the larger lecture rooms generally cause a number of projections in the facade, since the building usually requires long corridors, the vestibules, stair halls and the great hall afford opportunity for a richer treatment of the central portion; the long museums, drawing rooms, etc., require a great deal of light and therefore produce rooms like halls with narrow piers between the windows, numerous large windows.

To not increase the area of ground needed, more than necessary, some portions of these institutions for higher instruction require more stories than the rest. Thus richly grouped and treated designs result from the natural requirements. It depends on the special circumstances, whether and how these buildings should be grouped around a court or be arranged in connection with a system of gardens. Gravity and dignity of character are always suitable for their external appearance, and we should therefore avoid treating them with the cheerful and luxuriant magnificence suited to palaces and opera houses.

A large number of kinds of buildings are arranged in the following classification, less on account of their special purposes, than for their similar requirements. These classes are as follows.

α. Buildings that chiefly consist of a principal hall with which are connected subordinate rooms of all kinds, comprising legislative buildings, concert halls, exchanges, buildings for festivals, theatres, halls for dancing.

β. Buildings chiefly composed of offices arranged around courts and that may be connected with a large principal hall. ¶ This comprises town halls, ministries, post offices, telegraph offices, criminal courts with the hall for jury trials, banks, casinos and buildings for societies.

γ. Buildings chiefly consist of several halls of medium size with smaller rooms, comprising museums, libraries, record offices, buildings for art exhibitions.

δ. Buildings contain no true hall but rooms of different sizes, that adjoin corridors and are connected with a chapel; b benelovent institutions, hospitals, insane asylums, deaf and blind asylums, theological seminaries, prisons.

ε. Military buildings, barracks, headquarters, arsenals, guard houses.

ζ. Halls connected with rooms and smaller halls or without them, comprising large railway stations, market halls, produce exchanges, conservatories, buildings for industrial exhibitions.

η. Manufactories, mints, bronze foundries, abattoirs.

κ. Baths, observatories, aquariums, etc., cannot be placed in any class.

The buildings of any class have many things in common. The principal hall always extends in height through more than one story, is surrounded by galleries and boxes, adjoining it being buildings of one or two stories containing smaller halls, corridors and offices. These two story buildings may be grouped around corts. The hall then predominates over the rest of the building, whose ceiling requires a higher roof with lower wings, the lower stories being closed or with arcades with vestibules and stairways at their centres, as well as smaller halls in the upper story. The angles may be treated as pavilions, the courts being surrounded by porticos. For this group a special type is always developed in accordance with the special programme for the building.

B. Houses of parliament.

Houses of parliament where the state and the people are represented by the ministry and the deputies, require a dignified magnificence in accordance with the greatness of the realm by which they are erected. But their character should differ as much as possible from that of the palace of the ruler. Open

porticos, external stairs and towers, where bells are rung at opening and closing of sessions, convenient access and corridors are particularly adapted to these structures. The side wings containing the offices require a simpler treatment.

9. Concert halls.

These laways contains a large concert hall with galleries and boxes, which dominates the whole and requires a kind of basilican plan; vestibules, stairways, clothes rooms, promenade halls, restaurants for the public, halls for rehearsals with wardrobes and stairs for musicians, adjoin the principal hall. This usually produces an oblong building over which the hall must predominate. If these concert halls are connected with conservatories, they then require wings with rooms for instruction and administration, libraries, smaller music halls, rooms for servants, all these being arranged about one or two courts. The character of the concert hall should correspond to its purpose, which is enjoyment of ideal pleasures, and it should therefore be d dignified, but graceful and cheerful. All symbolisms referring to music are therefore peculiarly suited to this purpose.

10. Halls for dancing.

These consist of a hall for dancing with galleries and smaller halls, clothes rooms, promenade rooms, restaurants and play rooms; gardens and conservatories are generally added. These buildings exclusively serve as pleasure resorts and should have a cheerful character. They require little of the monumental, but may be constructed of building materials of less durability, employing any mode of decoration suited to the needs of the t time, and for playing a part in decorations for festivals.

Halls for festivals as usually erected in many modern cities nearly coincide in requirements with halls for dancing; in both must be provided a means of rapidly emptying the large hall in case of fire. Hence external galleries and numerous exits are desirable. Halls for festivals serve for the most diverse purposes of enjoyment and amusement, are often connected with extensive pleasure gardens, but differ from halls for dancing, because a much larger number of people must be provided for. The hall is also used for exhibitions and must dominate the entire mass of the building and be fully lighted, thus requiring skylights or windows in the upper portion of the side walls, and should also be fireproof if possible, while the hall for

dancing does not require lighting by windows, as it is generally used only with artificial light. In these buildings for festivals, as in those of class x, it is advisable for two reasons to arrange stairs in stair towers, because a clear idea of the arrangement of the stairs is easily remembered, and for the esthetic reason that the principal mass of the hall is contrasted with more slender masses of equal height.

11. Theatres.

These are dominated by the audience room and the stage. The audience room is generally semicircular, and its natural form should be expressed when possible. Vestibules, anterooms, foyers and principal stairways form a mass, which properly projects before the audience room with its galleries and boxes. All subordinate rooms are best placed in the side wings, that in exceptional cases include courts, as in the opera house in Vienna. The character of the theatre is that of dignity and grace, that of opera houses and comedy theatres is one of grace and cheerfulness. On account of the small durability resulting from danger of fire and the performances, attention should first be paid to securing the greatest safety possible. Monumental appearance is second as far as it corresponds to the dignity of the building. Therefore stone and iron construction play the chief parts, and wood should be used as little as possible, only where indispensable as in the stage construction. All materials of small durability but incombustible like sheet zinc, stucco and gypsum, may be used in the interior of the theatre with perfect propriety.

As stated in the preceding section for dancing halls, the arrangement of stairs in towers is proper for both practical and esthetic reasons.

Everything symbolical relating to dramitic art is evidently suitable as decoration. Gardens before the treatre, foyers and open porticos for the public, while awaiting the performances, are also appropriate.

12. Bank and office buildings.

Exchange buildings always require a great hall, which dominates the building, as well as a number of different business offices, with vestibule, stairways and other accessories. For t their characterization as distinct from other buildings, all

emblems and symbols are suitable, that relate to business; in order not to impair their characteristics a certain measure of decoration should not be exceeded, and also solid construction should be more considered, and decoration by the use of valuable materials procurable in trade, than a rich and magnificent architectural style, better adapted to other buildings. Banks and exchange buildings are suited by an ostentatious character, most properly obtained by expensive materials.

The group of kinds of buildings arranged under β is characterized by being composed of a large number of simmilar rooms for like purposes and with a uniform character, only modified by prominence of vestibules, stairways and separate halls, mostly placed in the upper story, therefore higher than the wings. They are more nearly similar to school buildings, but only in exceptional cases do they require as many and as wide windows, excepting in the halls. Hence long rows of windows usually occur and the buildings have several stories, sometimes two or three stories besides the basement and mezzanine. A plainer character is suitable for offices, dwellings and rooms for other purposes, a richer treatment for the halls.

13. Town halls.

These contain the offices of the city government, and thus many offices. Besides they comprise a large hall for assemblies placed over the extensive vestibule, and also large and spacious stairways. In many cases a tower is added, as already state, to contain a clock that strikes and also a bell for indicating the hour, with a room for the fire watchman.

The hall and tower require relatively richer decoration, thus giving the town hall its peculiar stamp. The offices need wide corridors, usually arranged around courts. A portico is placed over the vestibule with a balcony or open loggia opening out of the hall, to serve for announcements or for representations during festivals. These are then proper for the two lower stories of the tower.

14. Ministries, post offices, telegraph offices, courts.

Such buildings are almost entirely composed of offices arranged about courts and with corridors. They usually require several entrances and vestibules and sometimes several courts. Generally a richer mode of treatment should be rejected, and

one should be satisfied with a massive and solid style of architecture, which should be distinguished by the arms of the state, and any richer decorations should be concentrated on the portals.

15. Casinos, houses for clubs and societies.

Such buildings generally contain a hall for concerts and balls, in the upper story, as well as a number of very different rooms, used for recreation and placed in the different stories. The external treatment corresponds to the means of the society by which it is erected, and therefore varies greatly. With the use of abundant means, we should try to characterize the hall on the exterior, also when these buildings are connected with gardens, to make them effective by terraces, verandahs, etc.

Hotels are allied to this class and are evidently arranged and treated in accordance with their location, size and rank. The dining room becomes the principal hall.

Buildings placed in class γ have many things in common, because they usually have no principal rooms except vestibules, that require to be distinguished above others. They generally need numerous and large windows, no windows in halls having skylights, may have corridor-like loggias, may be decorated by porticos, and require a noble external treatment according to their dignity.

16. Museums, libraries, record offices, art exhibitions.

Little may be said in general of plans of these buildings, as this depends on the magnitude of the collections placed in them; also on whether these buildings may or may not be grouped around courts, or whether they have one or more stories. A chied requisite is safety from fire, and on this ground alone, with reference to their noble purpose, they are monumental buildings of the first rank, and solid construction is not only suitable for them, but also decoration by sculptures and paintings. Record offices must be entirely fireproof, but do not need artistic treatment of exteriors as much as the other buildings of this group.

The character of museums will vary according to the objects collected and exhibited in them. Collections of paintings and statuary are highest and require the noblest treatment. Libraries are suited by a dignified appearance with decorations by

statues and busts of the principal authors and sculptures relating to the departments represented therein. Art museums should be decorated by portraits of artists and by symbolical representations of the arts; collections in natural history by portraits of men eminent in that science and representations of distant parts of the world; ethnographic collections by representations of foreign races of men, etc.

17. Hospitals, deaf and dumb asylums, theological seminaries, prisons.

These buildiings grouped under δ have this in common, that they generally consist of many rooms of the same character, arranged around open courts with corridors or porticos. They are usually connected with a chapel, which affords opportunity for special treatment, while the other parts of the building remain plain. Prisons ackuire the character of gloom by their small grated windows, heightened by the heavy doors and by architectural elements of all kinds pertaining to fortifications. Hospitals and asylums should have a more inviting appearance in the parts seen by convalescents, even if simple, to make them more cheerful. Ornamental grounds, sunny porticos, beautiful views and whatever else that can rejoice the heart, will be benefilial and suitable in this respect.

18. Military buildings, barracks, headouarters, arsenals, Guard rooms.

The buildings of group ε are buildings of heavy appearance corresponding to their purposes, to which the solidity of their rusticated masonry and the Tuscan order are peculiarly suited, and reouire to be characterized by all having reference to war; simple forms as bold as possible, massive construction, decoration by tapestries, equestrian statues, battlements and many other expedients, peculiarly adapted to them.

Barracks produce a certain uniformity by their extent, that perfectly corresponds to military affairs, with a contrast by angle towers, massively treated portals and the facade.

Headouarter buildings contain offices and the dwellings of servants, therefore approximating the structures classed under β, but reouire the character of buildings intended for war purposes. Arsenals are principally magazines for arms, also in m many cases contain museums of arms, and they are sometimes

connected with manufactories of arms, cannon foundries, experiment stations, these being related to group n. In external design a large number of different buildings are arranged about an axis, whose centre is occupied by the museum of arms. Battlemented towers will serve as appropriate decorations for such arsenal buildings.

19. Railway stations, market halls, conservatories, buildings for industrial exhibitions.

Railway stations of higher rank always require large covered halls with which all other rooms are connected, or around which these are arranged. The waiting rooms are connected with large vestibules or porticos. Therefore the station is usually a central building with porticos and side wings, containing offices and the dwellings of servants. The front hall is parallel to the facade of a through station and perpendicular to those of terminal stations. Iron corresponds well to their nature and becomes a dominant element of designs for railway stations. Consequently these become structures of considerable extent, and their vestibules, wings, with perhaps a clock tower, give them a peculiar stamp. They are almost without exception massively built throughout.

Market halls, plant houses and buildings for industrial exhibitions are in great part structures of iron covered with glass with some portions in masonry. Their external appearance by the materials employed becomes very distinct and characteristic

20. Manufactories, mints, bronze foundries, abattoirs.

All buildings in this class are usually massive, being chiefly intended for utility. The uses of factories forbid a richer treatment as already stated, for the money should preferably be expended to benefit the workmen, than for decorating the building. Yet it is worth trying to obtain the most pleasing appearance with a moderate expenditure.

Mints are royal or state buildings and deserve a certain distinction, even if modest treatment is seldom exceeded.

For abattoirs, the decoration is generally limited to the entrance gates and the houses of the watchmen. Their purpose is well represented symbolically by heads of animals.

21. Baths, observatories, aquariums, zoological gardens.

Bath houses require large vestibules and waiting rooms. They

sometimes have conversation rooms, drinking rooms, covered promenades, restaurants, and all the appurtenances required for life at the baths. Adjoining them are bazaars, music pavilions, alllkinds of buildings for temporary occupancy, parks, places for games, etc.

Observatories are generally structures like towers with several basement rooms and having domed roofs for protection of the optical instruments. They may be decorated by all symbols relating to the heavens and astronomical research, with statues and portraits of famous astronomers, etc.

Zoological gardens may contain different kinds of structures. The entrance gateway with the porters' lodge are to be decorated to indicate the purpose of the garden. Restaurant for the public is an invitingly treated design with porticos for summer and enclosed rooms for winter, therefore furnished with heat. stables for the anidals usually have separate rooms for summer and winter, therefore being partly heated. They should have s special forms suited to the native haunts and mode of life of the animals, and they afford the architect an opportunity to design pecuialr and pleasing motives. Sometimes are cabinets of collections in natural history and in ethnology in these gardens, which are to be treated accordingly.

I. PLANS OF CITIES.

α. General.

After treating buildings in detail and then in general, as well as in relation to their respective kinds, we still have a series of topics for consideration relating to the objects that serve to beahtify a city, and which are included under the title of Plans of cities. If we examine the plan of any city, the first elements noticed are the streets, squares and gardens, by the intessection and parallelism of them it is produced. The blocks of houses, whose forms depend on the angle of intersection of streets, fill the interspaces between these elements.

Plans of cities have been developed in historic times in accord with local needs; they have grown naturally, and have developed according to already existing or newly created means of transportation. On the plan of the city has been formed on a fixed system, at the order of a ruler, or for the settlement of a colony, and all future additions to the plan must accord

with the system, as for example in Carlsruhe, Mannheim or Chicago.

The motives that determined the plans of cities were the following:- a, the castle of a prince or a cathedral formed the centre of the city; b, such a centre is wanting or consists of the intersection of two principal streets, generally at right angles; c, the city is only arranged according to the chief l lines of transportation; d, the plan is developed according to given conditions of the site, which perhaps prevent its extension in one direction.

From these result certain types of plans, which are complicated by the existence of several of these conditions. The fortifications of cities in ancient times, in the middle ages and until the recent period, essentially influenced the form of t plan. The principal types of plans of cities are therefore the followingy- a, centrally arranged plans; b, cross shaped plans; c, elongated plans arranged along a principal street connecting two neighboring places; d, sack plans, mostly placed in a valley surrounded by mountains; e, semicircular plans on rivers or next a mountain, lake or other obstacle, that only permits extension in three directions. Examples of central plans are found in great cities like Vienna, Berlin, London, Paris. Yet even in these cities a strictly central arrangement does not exist, from the operation of distinct conditions, and the general expansion of these cities has been modified by subordinate conditions. Thus Vienna with the cathedral of S. Stephen as a centre, was originally a semicircular centre with the Leopoldstadt beyond the Danube canal. Only after the different suburban cities had formed a ring was a truly circular plan produced. Paris and Berlin had ancient cities as a nucleus, located on islands around which the cities expanded. In Berlin the connection with Charlottenberg has become a principal line continued at an angle with the König street. The centre of Paris is occupied by the cathedral; of Berlin by the old palace, and the town h hall form two centres on two islands of the Spree.

All Wendish cities are arranged on cross plans. This was also a favorite with the Romans. These cities naturally have four city gates. Among modern cities, Mannheim is one of this kind.

We find examples of long plans in Augsburg and in Freiburg in Baden. Long plans are developed from former market towns, whose wide principal streets are likewise market places, for

example at Tölz in upper Bavaria and in the city of Steyr in upper Austria, located at the intersection of two mountain valleys. In the last place are two suburbs named after the rivers, while the principal city occupies a peninsula between the rivers, which intersect at an acute angle.

A characteristic example of the sack plan exists in Stuttgart, developed in horshoe form about its principal streets and hemmed in on three sides by the mountains and on the fourth by t the gardens of the castle, so that it can freely extend only along the valley of the Neckar and around the castle gardens.

Semicircular plans are produced in various ways, for example Mentz, Cologne, Kampen, Munich, Linz and others. The general type of these is that in which A is the old and B the modern city, Fig. 403, as at Cologne, Mentz, Kampen, Prague, and many other cities of medium size. If the cities become too large, the old and new cities form a whole as at Vienna, Prague, Dresden, Florence, Rome, etc.

Two principal lines of transportation, one being parallel to the river, intersect both city and its suburbs. If a tributary enters the main river at right angles as at Coblenz, Passau, Amsterdam, two suburbs B and B' are usually formed outside the old city, or the plan of the city is grouped in zones or ring streets like that of Amsterdam, which are intersected by streets radiating from a central point, called the cathedral place in Amsterdam. To the last group of plans belongs the fan-like one of Carlsruhe due to princely caprice. The founder of the city of Carlsruhe intended the net of radial streets from the chateau should form a complete circle and surround the castle garden, but his successors thought otherwise, and so the city has only extended on the west, south and east, the garden, forest and park forming its northern boundary. In like manner the ocean or an inland lake forms a natural obstacle to the development of cities located thereon. For example Naples is arranged on its beautiful gulf in semicircular form with radial and connecting streets.

All cities that cannot be placed in one of the given classes and having irregular plans were produced by a combination of the given conditions:- thus Genoa is hemmed in on one side by the sea, on the other by a circle of mountains; it therefore

has a principal street encircling the harbor and many ascending hilly streets. Rome was also more or less influenced by its seven hills; cities like Perugia, Bergamo and others have an elevated upper city and a low-lying lower city; Siena, Zurich, S Stuttgart, Baden-baden, etc., extend up the surrounding hills. Special obstacles also hinder the expansion of a city in various directions, as the Bois de Boulogne in Paris, the Thiergarten in Berlin, at Freiberg in Baden and similarly situated cities, the mountain at whose foot they originated.

It is only necessary to examine a volume of Baedeker's guides to recognize that the nucleus of most old German cities consists of a purposeless confusion of alleys hardly belonging to any type of plan mentioned; this is very simply explained, if we remember that the inhabitants necessarily built the fortifications as compactly as possible, and the streets or alleys were arranged to satisfy the most pressing needs. Much larger building sites were possessed by churches and monasteries, which determined the plan of communications. Convenience required rectangular blocks of houses in arranging plans of towns a and usually governed the division of plans of cities. Only after the removal of fortifications, when the city could expand beyond its old boundaries, was the central plan developed in most cases, and a ring street took the place of the fortifications, which were changed into agreeable promenades in many German cities, even forming the principal street in Vienna, on which are located most public buildings and finest private houses.

The entire esthetic character of the city essentially depends of its form of plan, whether rectangular or triangular blocks were adopted. Rectangular blocks are most convenient for buildings, since they only produce houses with rectangular plans; still if the system is consistently developed, the city assumes a monotonous and dreary character. Triangles with too acute angles should be avoided, since acute-angled corner houses seldom make a good plan possible.

Cities arranged on the rectangular system like Mannheim and Turin, or parts of cities arranged in the same way like the quarter around the Gens d'Armes market in Berlin have the disadvantage, that much time is lost, if one desires to go fhom a to d in Fig. 405, since he must travel the distance ac + cd, it being immaterial whether the dotted line is followed or any

other possible course along the streets ifs pursued to reach the point d. In case of a fan-like plan like that of Carlsruhe, acute and obtuse angles of different degrees are produced. The same will result from the expansion of cities carried out by plans if rationally executed. Let A, B, C, D, E in Fig. 406 be five neighboring places, which it is desired to connect with a city as a nucleus. It will then be best to arrange five principal lines of communication to the different places, connecting these principal streets by ring streets. It it is desired to avoid acute angles, the vertices may be truncated and public squares be arranged at the intersections of radial and cross streets, so that this again recurs to the block system. B Baumeister in his work on Extensions of cities, exhaustively discusses this and other questions, which do not require our consideration, except as they influence the esthetic appearance of a city.

The external appearance of streets and squares, the character which should be given them by the architect, depends on both the entire plan and on the character of that quarter of the l city intersected by the streets. On the whole, one may distinguish three principal kinds of the parts of cities:- 1, business quarters, 2, residence quarters; 3, industrial quarters. Baumeister has very clearly stated on p. 80 of his work the conditions under which the character of the streets result from these. We shall briefly consider them.

The business quarter preferably occupies the nucleus of the city and extends toward the parts, where the seat of the administration and the city government, as well as the most important public institutions are to be found. Thence results the principal ground law, that contiguous principal streets are best adapted for shops and business offices, more quiet side streets being for residence and intellectual work.

The external portions of the city will always be best suited to the better residences if the means of communication are properly cared for, since the cheaper sites and the pleasure of a rural life lead to this end. The western side will preferably be occupied by the villa quarter on account of the prevailing western winds, affording the purest air.

Manufacturing and wholesale trade is preferably located with reference to natural and artificial transportation. Harbors,

ls anc rivers determine the centre cf the location cf the esale business, the smaller value of the land in the outer ions cf the city as well as the need cf more space and the ness cf the great lines of communication, compel the loca- of the manufacturing quarter on the outskirts of the city. minor industries, mostly connected with shops, as well as retail trade in general, are scattered over the entire city.

b. Streets.

erefore the streets of a city will generally follow certain s with which their characters generally agree. They are p cipal streets, main lines of communication, or side streets, ecting the former or dividing a part of the city into blo- of houses, and finally narrow alleys. They are further vil- treets, palace streets, streets of communication, and the ets for the poor. The principal streets are also main lines ommunication, and building sites are dearer on them than he side streets; hence to make the best use of the ground, requires the buildings to be 4 or 5 stories in height. ground floor is chiefly occupied by the better warehouses. ccording to local conditions, these principal streets have or four rows of trees. On account of the noise of carriages in the street, these principal streets are not preferred he best society. The houses are chiefly for rental, and t r owners try to attract wealthy tenants by richly decorated des. Therefore in order to make the best use of the capital, s proper to arrange a mezzanine story, above this being p ed the best story containing only a single residence, then above are two flats in each story. The owner of the house himself occupy either the mezzanine or one of the upper s. In this way originates the type of the richly decorated tial houses for rent, like those on the Ring street in Vi- , on the Linden, Potsdamer and other streets in Berlin. prevailing character of the better class of houses for al in Berlin consists in the use of bay windows with balc- s, certain types of which are most common. In the simplest ples the bay window commences above the ground story and as a balcony below the upper story. This motive is more ly developed by verandahs at the sides, so that the bay ow usually extends into the basement story, forming a small rance hall. In double houses, that are afvorites in Berlin,

each house has its bay window, and both are connected in the best story by balconies, or even in several stories. Bays that commence in the basement stories can evidently only be arranged where the house is back from the street line.

It is seldom that palace streets are found consisting only of palaces of princes and nobles, also of public buildings. A part of the Ring street in Vienna and also of the Linden in Berlin may be mentioned here. These differ from other streets in that the basement story exclusively contains living rooms as well as the offices of the manager of the building. The Heerengracht in Amsterdam, a part of Via Balbi and Via Nuova in Genoa,may properly be called palace streets, like many streets in Paris and other large cities.

Villa streets are found in most plans for extension of cities, are chiefly characterized by the usual occupancy of the villas by a single family only, and it therefore contains only a basement and a first story, also it is detached and surrounded by a garden. Therefore while the previously mentioned principal streets are bordered by higher buildings for rental, the villa streets are mostly low, quiet and inviting, little affected by noise in the streets, and more frequented by persons w walking for recreation. The gardens in front of the villas are often so deep, that the villas can only be seen from the garden gates, and the entire street has the appearance of a street in a park. Garden porticos, trellised porches, pleasing garden fences or low garden walls and their entrances, etc., give the villa streets a peculiar stamp. These types of streets are seldom carried out in purity, but are mixed more or less, thus in many cities, there is a small garden before each house in a s street, even if they are built in blocks; and in other streets, palaces and houses for rental alternate with shops, hotels and public buildings, as in the western portion of the Linden street in Berlin, in the western part of Leipziger street there, and in Maximilian street in Munich. The eastern part of Ludwig street in Munich is almost entirely occupied by public buildings, etc. But where circumstances develop naturally, a typical character of the streets will always be an aim for their inhabitants. The wealthy will always prefer to occupy their own houses with only their own families, and thus prefer the villa to the rented dwelling, which will be left to persons possessing

less wealth, such as military officers, officials and other p persons, whose occupation makes removal to another city possible. Many cities have quarters preferred by persons pursuing certain occupations; thus men speak of a professors' quarter, a quarted for privy councillors, an artists' quarter, etc. In other cities as in Paris, London, Amsterdam, Hamburg, Danzig, etc., it is indeed a very common or an exclusive custom for each man to occupy his own house, whose small size is the reason for the arrangement of living rooms in several stories.

Side streets and alleys will be more or less occupied by citizens of modest station, so that architectural decoration of the houses will be omitted, and they will only contain business locations of lower rank, which chiefly satisfy the needs of the daily life of the inhabitants. These streets descend by degrees to the streets inhabited by the poor, and only occupied by the lower class. In recent times it has been rightly attempted to better these dreary quarters by attractive dwellings f for workmen. There are streets for communication, only containing business places with few dwellings which consequently assume a uniform character with a moderate architectural treatment, although the number of persons passing along them may be very great, as in portions of the boulevards of Paris. Allied to these are the canal streets like those of English and Dutch cities, and of Hamburg, almost entirely occupied by warehouses. Usually a navigable canal lies between two streets or close to a single street, as in must Dutch cities, less frequentln extends along the rear of the houses, which facilitates unloading goods and their removal into the warehouse. In Amsterdam the character of these canal streets is elevated by intermediate steps from an absolute lack of decoration to palace streets, the Heerengracht being almost entirely occupied by the aristocracy of wealth.

Most goods will be transported by canals when bulk and cheapness are considered more than speed, like raw materials and bulky manufactores: reloading must be avoided as much as possible Utrecht is most favorably situated, as most of its canal streets have canals at sucth a low level, that cellars are arranged under the pavements of the streets, through which goods are carried into the buildings over a quay. The quays are planted with trees, whose foliage commences at about the

level of the pavement. The streets then have the section shown in Fig. 407, which gives a very peculiar arrance to Utrecht.

Venice is often improplerly compared to Amsterdam, but the canals do not form lines of transportation for goods, but for persons, since the principal facades of palaces and houses lie on the canals, their rear being toward the streets. The general appearance of the Grand canal rises to that of a palace canal in many places. all alleyu in Venice are narrow, so that no carriages of any kind are used there. Venice and Amsterdam therefore form the must peculiar contrast. The principal points to be considered from an esthetic point in enlarging the plan of a city, Baumeister comprises in these laws; symmetry of groups of buildings, picturesque perspective of streets and squares, well chosen points of view, attractive arrangement of the masses of buildings.

e: Squares:

These are intended to afford space for crowds of men in those parts of the city where travel is very great at certain hours. They have the further advantage of aiding a good circulation of air, and are the natural ventilators of cities. They also pleasantly interrupt the monotony of the connected streets, and add much to the picturesque character of a city. In earlier cities, hemmed in by fortifications, squares were frequently obtained after the removal of the fortifications by tearing down churches and monasteries.

Localities in cities where travel is exceptionally great at times are:- 1, intersections of streets; 2, at particular buildings. Since the square is not a luxury but a necessity in a city, it must be adapted to an increase of travel; squares too large cause heat and dust and may embarras travel.

1. Squares near churches. On account of filling and emptying a church at the beginning and end of divine service, as well as for processions in case of Catholic churches, cathedrals a and churches usually need squares of considerable extent. The square is usually located at the western end of the church, so that the principal facade forms the terminal axis of the square. In other cases the square also extends along the south side ((Fig. 408 a), as at Regensburg and Strasburg cathedrals. In yet others it also extends along the sides, leaving but an alley behind the choir (Fig. 408 b), as at Freiberg, or the church is

entirely isolated.

Older fortified cities were frequently compelled to surround the church on three sides with houses or it was built up on all sides, which incluenced the plan (Fig. 408, c,d). Or the proximity of an existing cathedral allowed the architect to give an isolated church an abnormal form, like the Liebfrauen churches of Treves and Mentz. The location of a church on a hill generally affected the arrangement of its square. The largest and finest church square is that before S. Peter at Rome.

2. Castle squares. Most princely castles required a castle square for military reviews. Hence the castle square is in most cases the richest and most stately in its decoration, of all in the city, and more so if other royal buildings, theatres, museums and libraries are located around it.

3. Squares before town halls are frequently used as markets on certain days. Town halls represent the people and therefore usually placed near squares of large size, where citizens could assemble on special occasions. State buildings for officials, barracks, higher educational institutions, post offices and prisons seldom require squares, though generally built near them to decorate the squares. Buildings for societies, police stations, fire engine houses, schools, laundries and baths, abattoirs, market halls, industrial halls, cemeteries, etc. generally require squares or should be adjacent to them.

Baumeister gives in his work a series of the most important types of plans of squares, which may be briefly indicated.

1. Four streets meet with acute and obtuse angles (Fig. 409, 1,2,3). The vertices are truncated obtaining eight obtuse angled buildings are obtained as at 1. In No. 2 the pairs of corner buildines are similar with two rectangular ones, while in no. 3, adjusting the irregularity of intersection of two streets with a third at different angles, there are two rectangular and four with different angles. If the blocks of houses are arranged on the rectangular system, several different cases may occur. 2. Two opposite blocks of houses are shortened (4), or two streets intersect and angles are truncated (5), or lastly the square lies between the extensions of two streets (6).

Combinations of both arrangements when streets intersect at right, acute and obtuse angles, give the arrangement No. 7, as

well as 8 to 12 (Fig. 409). If several principal lines extend through it as in the last five examples, the square is peculiarly adapted for decoration by means of buildings, fountains, gardens, etc. An enlargement of a continuous street on one or both sides is admissible at those points where travel increases, according to sketches 13 and 14 (Fig. 409), as in Leipziger and Pariser streets in Berlin.

Monuments, fountains and gardens, porticos with seats, are the most beautiful decorations for squares, with lamp posts f for lighting by gas and electricity. Gardens are peculiarly adapted for the decoration of squares; lawns, shrubbery and trees heighten the picturesque character of the squares and afford for the eye a beneficial change from the turmoil of the city. Still, these designs should not injure the appearance of the buildings, and their height and extent should be suitably limited. It is proper to conceal urinals by shrubbery.

Enclosed gardens or the so-called parks are not well adapted for open squares. They are sometimes so arranged as to form t the central point of a group of buildings, which adjoin the street on but one side, but abut on the four inner sides of t the park (Fig. 410). This produces inviting and quiet residences that may be very near the principal streets, though removed from their noise.

Monuments, fountains, ponds, seats, kiosks and beds of flowers serve to ornament such squares. To them which are sometimes called gardens, by which travel should never be obstructed, also belong larger squares covered by gardens or plantations of trees, like the Hofgarten in Munich, the Schloss Platz in Carlsruhe, Lustgarten in Berlin, Champs Elysees in Paris, etc. Smaller and more numerous squares are preferable to a few large ones in any city.

d. Gardens.

Many cities have large parks and palace gardens in their suburbs, like the Prater in Vienna, Thiergarten in Berlin, Bois de Boulogne in Paris, English Garden in Munich, Schloss Garden at Stuttgrrt, Carlsruhe, Darmstadt, etc.

When such gardens or parks exist naturally or even artificially, they should be cared for and beautified as much as possible. They are the principal places of recreation for the city,

sometimes containing pretty bodies of water, ponds and streams, and they are much visited on certain days in summer on account of military music, and their borders are favorite places for restaurants and places of amusement. Many cities must be satisfied with promenades, arranged on the site of the ancient fortifications, for the lack of such gardens; this is the case in most cities in Holland, of which only Amsterdam, Haarlem and Hague have their noble parks. Ancient cemeteries no longer used for burials are sometimes transformed into parks. Places for games should be arranged in cities as well as botanical and z zoological gardens, baths, places of amusement with palm gardens on the model of the palm garden at Frankfort, Flora at Cologne, and that of Charlottenburg. One should further never n neglect to arrange seats in gardens and squares, as well as p porticos, where opportunity offers, that persons may shelter in case of rain and may promenade. Only monuments should not have seats near them, because these only afford too ready opportunity for defacing the monument.

C. WELLS AND FOUNTAINS.

Except monuments, the most beautiful and suitable decorations of squares are wells and fountains. Markets require cleanliness and therefore fountains, which are now merely hydrants with l large tanks, their centres occupied by a pedestal supporting a large shell, a canopy or a statue or group of statues, or a structure like a tower like the Schöne Brunnen at Nuremburg. The market fountain is a running fountain. There are several other types of wells or fountains:- 1, the well, well house, enclosed spring. 2, the running fountain; 3, spring wells and fountains; 4, cascades and water decorations.

1. Cistern wells are vertical and usually round shafts sunk to the water level, sometimes to a depth of several hundred f feet. Furnished with a curb at top with some arrangement for raising the water, merely a bucket and chain for wells of small depth. The well curb must be formed so that the full bucket m may be set on it, and its exterior may be ornamented by reliefs. The finest examples of such curbs are the bronze curbs in the court of the Doge's palace in Venice, that are circular internally and octagonal externally.

The shaft of the well itself is even treated esthetically in

some cases, sometimes as a winding stairs with open well in t the lower part of it being a basin for collecting the water. Such a well belonging to the mediaeval period and of square section is the so-called Jew's bath in Friedberg in Taunus, and we have an example from the Renaissance period in the well of Antonio Sangallo the Younger at Orvieto, begun after 1,25. The latter is of circular section.

In most cases the bucket is suspended by a chain that runs over a pulley. The pulley itself must be supported in any suitable manner, and a series of motives are thus produced which have been executed in many places. Sauvageot gives a beautiful well with two buckets, one supplying the garden of a monastery, the other a street at a lower level.(Fig. 411). Two piers of different heights support a horizontal stone beam strengthened by decorative additions at the middle, to which the pully is fastened. Over the piers free terminals are added as decorations of the stone beam. Wells of this kind are not infrequent in the cloisters of Italian monasteries. They are usually placed at the centre and are elevated on several steps. But they may also be attached to a wall into which the end of the beam is built, the other end being supported by a column (Fig. 412). This motive may be tunned to good account by making the beam quite long, arranging that one can pass around the well (Fig. 413). It will then be advisable to place a corbel between the beam and its supporting pillar, which may be formed in various ways. If the well is distant from the wall, the stone beam may be replaced by an iron beam, then let into the block that supports the pulley. A very graceful late Gothic well of this kind stands in the court of the Gymnasium behind the choir of the cathedral in Strasburg.

A further development of the well is produced by placing a strong covering slab above three or more piers supporting the pulley. The centre of the covering slab may be strengthened, which originates the motive of distinguishing this centre by decorative additions, as well as ornaments placed above the piers, statues and ornaments; the German Renaissance has left many such wells, the motive being improved by wrought iron work. This motive of the canopy well is developed in larger designs of similar character in a small polygonal structure. (Fig. 414).

An example, though more simple than the one shown, is found near the church in Veere in Holland, where the rainwater is c collected on the roof of the church, led in a channel E that runs around the cistern, the impurities being deposited in it, while the clarified water flows into the collecting basin by openings filled with bricks set near each other; thus only the water can pass through the slits as shown in Fig. 415. The channel E and tank A may be accessible by steps. The pulley for the bucket chain is supported from the keystone of the vault. In very deep wells the weight of the chain and the buckets is too great for the chain to be simply drawn up by hand; in such cases as in derricks, a windlass is substituted for the pulley, to which the chain is fastened, and this is supported by two bearings. A wheel is attached to the axle, which is then turned by both hands, while the chain is wound on the axle. A ratchet prevents the wheel from slipping out of the hands. Then the raising of water by machinery requires projection by a roof, so that iron parts may be as little as possible exposed to rust. The whole design of the cistern is then detached and covered by a building, or is placed in a niche of the wall and covered by a protecting roof.

Well houses are usually employed where a spring is treated like a well and is placed under a roof. The spring is then enclosed to serve for drinking, so that the surplus water is removed. Mineral springs in particular require attention to be devoted to both these points. In cities like Baden-Baden, where naturally hot water is obtained in such quantities as to be u used for economical purposes as well as for drinking and baths, public fountains are usually arranged as niches in the walls, and the outlets for water are closed by stopcocks. Special drinking halls are generally planned where the water is drunk.

Other designs for fountains are arranged like small open t buildings, where the water runs from one basin into another l lower one, then into a third, etc., so as to remove all vestiges of impurity. Such fountains are vaulted with open rooms at one side, belong to the mediaeval perior, and still exist in several Italian cities, as in Siena. A few similar spring houses also remain in Germany and France.

Larger designs for springs also consist of an open basin with

a chnnel for removing surplus water, and one descends to the basin from the higher ground level tn a flight of steps. A fine example of such a design is afforded by Donauschingen in its so-called source of the Danube.

Between the cistern wells and flowing fountains are pump wells, which are seldom public wells but are found in courts of private houses, and are therefor seldom decorated. The cistern is then covered by a stone slab at whose centre stands the pump, usually of wood with a swing handle. It is also made of stone or cast iron, and is then treated like a stone pillar with cat and free terminal ornament, or a cast iron column with any form of capital supporting a statue, lamp, or free ornament. The handle of the pump may have a decoration at its upper end by iron bands like volutes to avoid its swinging sidewise. Below the spout, often treated like a rain spout, as the head of a lion, dolphin or dragon, etc., stands the basin, most simply a hollowed stone slab, but in more pleasing designs beink like a vase resting on the base of the pump and crossed by oron rods at top, on which the water pail is placed, (Fig. 416).

2. Running fountains principally differ from cistern wells in being supplied by water acqueducts or springs led through pipes from a reservoir higher than the outlet. According to t their arrangement, they are either wall fountains or detached fountains. The former are often placed in courts, are niche f fountains in the front of the basin and project little from the face of the wall (Fig. 417). An architrave like that of a door decorates the niche, and this may be developed into a canopy with pilasters, columns, pediments, etc., while the front of the basin has space for any decoration in relief. In circular niches, the upper part is ornamented like a shell, a horizontal band being carried around at the height of the springing, and in case of richer treatment the discharge pipe may be connected with a statue in any way. The fountains in the courts of Italian palaces as well as the sacristies of churches are mostly formed in accordance with the same principles, the basin is composed of or covered with marble slabs, and is sometimes of cast bronze. Another arrangement if wall fountains is to place the basin before the wall face, so that the niche is shallow; this arrangement would be ouite suitable for the corner

of two streets meeting at an acute angle (Fig. 418).

A third arrangement is particularly adapted to be placed under the landings of ramps or stairs for terraces, aquariums or fishponds, lighted from above, is to arrange a well house, which is to be regarded as an enlarged niche. These three modes of arrangement may usually be varied in many ways, and treated according to the principle of decoration of niche fountains, may be developed into grottos of all kinds like those in so many Italian gardens, as well as in water decorations c of the late Renaissance. Imitations of stalactites, tufa, glittering minerals, shells, figures spouting water, dolphins and dragons, silenuses, serve to ornament such grottos, which were also favorites at courts of French and German princes. Such grottos exist at Versailles, Sanssouci, Schwetzingen, Wilhelmshöhe near Cassel with its water ornaments, as well as elsewhere.

The simplest form of detached fountains may be treated like pump wells. In richer designs the number of water basins and discharge openings would be increased, and a corresponding form of plan be selected (Fig. 420). The most varied forms are especially possible in the larger market fountains, whether t basins are set in tiers above each other, or a common basin is formed. The upper basin may also be accessible by steps.(Fig.421).

Evidently the varied simple anf combined polygonal forms (Figs. 422) may be used to good advantage as the systems of plans of such market fountains, and may vary according to whether they are connected with stairs, seats, or gas lamp posts, or an upper group of water shells is formed besides the common tank.

As a means of decoration of these and other designs of fountains, all animal, plant or purely ornamental forms are suitable, if they have reference to the water. The front side of the basin may have reliefs of all kinds; the central pillar of the fountain (Fig. 423) consists of a plain rectangular or circular or polygonal body a, mostly in the water, a second t contains the discharge pipes, and may be decorated by inscriptions, coats of arms, reliefs, etc. Above this is the base c with plan suited to that of the lower portion, and above is a cap that may bear a statue, a canopy or lamp post d. The upper basins may be formed as vessels or shells; care must be taken that they do not appear too massive if seen from below. It is a favorite idea for market fountains to add water-spouting

statues in suitable places, even on the margin of the basin, to enclose the entire fountain by an iron grille, so arranging it that in spite of the grille, a pail may be filled. For this purpose parts of the basin may be corbelled out or openings are formed in the grille at proper places.

3. Spring fountains and fountains. For these the same is more or less true that has been said concerning running fountains, but with this difference that they perfectly serve a purely decorative purpose, and are only employed in gardens, as a means of obtaining water, being connected with basins for gold fish or water plants. The simplest form of spring fountain consists of a shell on a pedestal; richer forms have several shells over each other, the lower fed by the upper. The whole may be surrounded by a single basin. The shells may be replaced by groups of shells, and the pedestals may be in form of short columns, a clustered pier, the lower part of a vase, or figure sculptures. Discharge openings take the form of simple tubes, flowers, mouths of animals, or man be connected with statues. It is evident that the greatest latitude is possible in the treatment of fountains; thus a well known spring fountain in Rome has the form of a boat, and the one in Piazza Navona is crowned by an ancient obelisk. A rich contrast of falling and rising streams of water overflowing shell basins, shell like mouths at discharge openings, sometimes make real water ornaments of spring fountains. They may also consist of an islet in a basin treated and ornamented by statues supporting the water shells; it may further be enclosed by a canopy structure or it may decorate and cool the interior of a room.

4. Cascade fountains are purely ornamental in purpose and are architectural works with considerable volumes of falling water. They may be merely architectural like Aqua Paola in Rome, with three great streams of water pouring down from a gate-like structure before a triumphal arch, and floying into a collecting basin. Or in front of an architectural background, is constructed natural or artificial rock work, from different parts of which water gushes into a great basin as on Fontana Trevi at Rome. Such cascade fountains may be developed into extended water ornaments by sculptures and plant ornaments in connection with buildings, flights of steps, bridges, grottos,

etc., as at Sanssouci and at Wilhelmshöhe in imitation of those at Versailles.

The wall enclosing the basin may be formed like a seat (Fig. 424), whose back must have sufficient height, that a child standing on the seat cannot fall into the water; for this purpose the coping may be crowned by a low iron railing to prevent one from climbing over the enclosure of the basin.

V. MONUMENTS.

Besides fountains the principal decorations of streets and squares are monuments, for which we have only to consider memorial and not sepulchral monumentss. In all cases a distinction is made between the object to be supported above the ground, the pedestal, and the base or foundation.

According to the object supported by the pedestal, we may c classify eight different kinds of isolated monuments.

1. The object consists of emblemsl a cross or an obelisk, a tower structure (monument on Kreuzberg, Berlin).
2. A bust is supported.
3. A statue is supported.
4. Two statues are supported.
5. An equestrian statue is the object.
6. The principal figure stands on a pedestal surrounded by 4 or 8 subordinate statues.
7. The monument has an architectural background.
8. It is purely esthetic, decoration by statues subordinate.

There are two primary requirements for monuments of all kinds; they must have good proportions of masses, and if isolated, t their outlines must be pleasing. Unfortunately both requirements are seldom satisfied, since the training of the sculptor is too slightly architectural, and he takes advice from the architect only when the idea of the composition has been already decided. Thus for example, the Luther monument in Worms is faulty in arrangement; the subordinate figures stand on the enclosing wall and give the whole the appearance of a chessboard, on which stand several figures. It should be a first condition of an arrangement on the plan (Fig. 425), that the statues at a should in some way be connected with the monument proper at b.

In the Luther monument in Worms all the statues like that of Luther himself are looking in the same direction toward the e east, which has an unpleasing effect, the monument is also not

orientated at right angles to the axis of the street, but is parallel to it, extendind from east to west, which must be considered a mistake, when the monument is not placed in the middle of the street itself like that of Frederic the Great in Berlin, but stands at the side of the street.

The Schiller monument in Berlin must be regarded as being quite faulty, both in proportions and in its dimensions relative to those of the square in which it stands, since the structural masses of the treatre or of the two churches on Gens d'Armes market required a bold and massive structure. The monuments in Berlin most pleasing in proportions are Schinkel's monument of the great elector and Rauch's monument of Frederic the Great.

In regard to proportions and effect of outlines, these will always be decided by the proportions between the pedestal and the object supported by it, and which prescribes its plan. If we conceive that a cube rests on a slab and supports a pyramid, (Fig.426), the proportions of the masses viewed diagonally w will be completely changed and may be unpleasing; had we drawn a cylinder with height equal to its diameter and supporting a cone, instead of the cube and pyramid, its appearance would be the same from any point. If we employ a form intermediate between the two, we have two choices of a form for the monument, either the octagon or the cross (Fig. 427). Circular, octagonal or cross pedestals always look best if viewed diagonally. It is preferable to make the pedestal of such form as to produce a gradual transition from the square to the cross, then to the octagon and finally to the circle. If we again return to the simplest case and insert a cap between the cube and the pyramid (Fig. 428), its projection will conceal a part of the pyramid and thus lessen the object supported by the pedestal. As it is really the principal part of the monument, the pyramid should appear as large as possible, hence a special base is properly given to it, whose mass is in a pleasing proportion to the mass of the pyramid. If the base is too massive, the pyramid looks small, and if too low, it does not act as a mass. If an obelisk is made the principal object of the monument (Fig. 429), or a memorial column instead of a pyramid, the mass of the base would appear unpleasing in proportion to the obelisk.

On this consideration are based the good and bad arrangements

of monuments. On most monuments the proportion between object and pedestal is therefore unpleasing, since the pedestal is made too high, propucing too massive an effect. It too frequently looks like a tile stove. Therefore it will always be proper to insert a speceial base between the cap of the pedestal and the principal object of the monument, thus reducing the total height of the monument by a substructure in parts. One will never fail if these ground laws are obeyed, as Rauch did in his monument of Frederic the Great.

A second point requires notice, that the pedestal and the base of the object must be so arranged with reference to the object, the treatment and the decorations in relief, that the object becomes the principal thing, or that a contrast is produced between the treatment of the object and the more or less detailed treatment of the base portion.

Thus an equestrian statue agrees with a richly treated base above a more simply formed pedestal, statues with rich drapery or richly detailed costumes, a standing or crouching lion, a dragon fight, etc., will require plain and simple bases and pedestals, to retain the contrast. Thus the development of the architectural mouldings of the base and pedestal essentially depends on the degree of detali in the principal object.

To treat a monument as a sham fountain from which no water flows like the Schiller monument in Berlin, is a coarse offence against the external and internal truth of an art work.

The ascending steps that form the substructure of a monument should recall the steps of stairs as little as possible, and therefore should be so profiled that rain water may speedily run off, and that their purpose may be apparent to the eye. (Fig. 430). Inscriptions are best cut with a rectangular section of the letters; incisions with triangular section easily become illegible by exposure to weather. To arrange seats on the monument itself is improper, since it may easily be defaced. But it is suitable to place seats in the vicinity of the monument so that it may be seen with ease.

1. In monuments whose principal subject consists of emblems or objects of any kind, except statues, the base and pedestal should be arranged to accord therewith. A fine motive of such monuments is shown in the obelisk fountain in Carlsruhe (Fig.

431); an obelisk is flanked by two griffins, lions, river gods, etc., whose massive oblong pedestals project beyond the square of the obelisk; the latter is utilized as a running fountain, whose two basins may project beyond the pefestal at its sides. The same motive may be utilized in monuments with statues.

2. Monuments with busts usually have a proportionally high pedestal that receives the inscription; to prevent this from having a too massive effect, a special base may be inserted b between the cap of the pedestal and the bust. The busts may stand free or may be placed against the rear walls of porticos, or also be arranged as memorial fountains. The busts may be protected from rain by a canopy-like stbucture.

3. Especial care must be taken in case of detached monuments with statues, that they have good proportions on all sides, a and that they diminish properly upward. Therefore it is proper to cover the figures with mantles, which conceal the spaces between the legs, to place emblems at the feet of the figures, pedestals supporting an arm of the figure, and similar accesscries, which give the chief object a broad base. Hence in many cases, sitting figures appear better than if they were standing, since their lower portions are broader. In monuments with statues, the pedestals usually look too broad when viewed diagonally, and the angles are therefore usually truncated (Fig. 432). In more richly detailed pedestals, the angles are flanked by pilasters or slight projection, and an entablature is i inserted between their capitals anf the cap.

4. Monuments with two statues as a rule require an oblong p pedestal, with its broader side at front. This broad front side then requires, so as not to seem empty, to be divided by reliefs, inscribed tablets, and like accessories. Figs. 433 and 434 represent the base of such a monument at Geneva, executed after designs of Professor Nicolai.

5. Equestrian statues likewise need an oblong pedestal, but its end is in front. The bold mass of the body of the horse forms an esthetic contrast to the pedestal, at whose base angle statues may be placed. Among the most beautiful equestrian statues are the monuments of the Great Elector, of Frederic the Great, that of Colleoni in Venice, the angles of the pedestal being decorated by columns.

6. One of the most extensively employed types of monuments

is that where a central statue is surrounded by four angle figures. An increased development in height results in such monuments as well as a pyramidal enlargement downward. It is preferable for these monuments also to make the pedestal lower, placing the principal statue on a special base (Fig. 435). Most seated angle statues likewise have separate bases.

Sometimes four subordinate statues are placed between the angle statues, or groups of emblems, coats of arms and other symbolical or ornamental accessories. These may be so arranged that the lower part of the pedestal is separated from the upper portion bya cap, and independently developed architecturally , so that the upper part becomes a low frieze, flat or decorated by reliefs. In this way the mass of the pedestal can be more richly treated, and its beauty of proportion be increased by these subdivisions.

7. The treatment and proportions of an architectural background of monuments must be arranged in accordance with the monument when serving as a foil to heighten the importance of the monument. Thus the statue of Bavaria in Munich is surrounded by a hall of fame, and in the competition for the monument of Victor Emanuel, a triumphal arch was placed in the foreground, beneath it being placed the actual monument. The architectural surroundings of a monument may evidently be arranged and treated in the most varied ways; not too large a scale will always be preferable for the architecture, so that the monument may be as prominent as possible. Michelangelo well understood in his tombs of the Medici as well as in the monument of Pope Julius II, how to make the statues themselves more imposing by the small scale of the architectural background.

There remains a word to say in regard to monuments, which are not detached or isolated. They are generally arranged as niche monuments attached to a wall, and the architecture of t the niche forms the principal motive of their treatment. The motive of the triumphal arch was frequently used to good advantage in the more extended designs of this kind. Four niches, each containing a statue, are also combined in a detached monument, that terminates at top in some form of roof. (Fig. 436).

8. Purely esthetic monuments are usually arranged according to a few ground types as memorial columns, tower structures, temple buildings, and also as statues arranged around a centr-

central point. When the memorial pillar is of slender proportions, it may take the most varied forms (Igel column near Treves, monument of Columbus at Genoa, Memorial column in Neustadt at Vienna, Mary's columns of Rococo perior in different cities of Austria); in larger designs it was usually treated as a column with capital, whose abacus is accessible by a winding stairs (column of Trajan in Rome, Column Vendome in Paris, Monument of victory in Berlin). Monuments like towers are either solid (monument of Lysicrates, monument on Kreuzberg in Berlin), or are arranged to serve as towers for observation.

These may also be treated in different ways according to location. The substructure containing the entrance to the stairs or an elevator, (towers of Trocadero in Paris), sometimes forms an extended architectural design, sometimes with the form of an open portico, that of a chapel (Fig. 43, a), or finally a cross shaped substructure b, with centre occupied by stairs. In arrangement a the stairs may be placed in an apse, so that it is first connected with the central stairs above the vaults.

We have a characteristic example of temple and centrally arranged plans in the Walhalla near Regensburg and in the Ruhmeshalle near Kehlheim. Such designs with which are to be classed lookout pavilions, like the Gloriette of Schönbrunn near Vienna, do not admit of a general discussion, being entirely free compositions, probably the freest and most pleasant problems of the architect, permitting a multitude of solutions.

W. CITY GATES; TRIUMPHAL ARCHES.

Now that most cities have no narrow circle of fortifications, a principal motive for the treatment of city gates entirely d disappears, that gave the gates a certain character in early towns, the gate tower that sometimes only served to contain a portcullis or drawbridge, or sometimes the prison, or guard.

City gates have become obstructions to traffic according to modern ideas, and one is disposed to remove them, rather than erect new structures. If they have been retained from consideration for esthetically important older gates, the old fortifications have usually been torn down at right and left of them, and the traffic near the gates is thus falicitated. If new gates are erected, the plan of the streets is generally arranged so that the larger central opening is used for wagon traffic, while the smaller side openings serve foot passengers. Yet such

modern gates eventually proved too narrow for the traffic, so that they were entirely isolated like the Propyleum at Munich, or passages later arranged at one or both sides as at the Brandenburg gate in Berlin.

Gates are frequently flanked by guard houses, or by buildings for collection of the octroi duty. Thus results the usual arrangement of tree openings between wings. If the central gateway is covered by a semicircular arch as well as the narrower side openings, the motive of the triumphal arch is usually the most natural design.(Fig. 438). The middle part is generally crowned by an attic and group of statues, a quadriga or other symbolic decoration, and the wings are covered by platforms reached by stairs, and their parapets may have battlements. Such platforms are peculiarly suitable for seeing life in the streets during festivals, and open boxes may be arranged over the side arches for the same purpose. Where wings are unnecessary, external s stairs may be placed to make the attic accessible. If streets terminate without a gateway, their ends are preferably marked by squares and by corner buildings of more importance. Gateways in the interior of a city usually result from the passage under a railway. In the better quarters they especially require artistic decoration, which should at least comprise a pleasing and bold limitation of the masonry forming the railway viaduct. The same is also true of railway tunnels inside cities. Thus the tunnel under the castle of Heidelberg should have been constructed at somewhat greater expense.

X. BRIDGES, RAMPS, BASINS FOR WATER, HARBORS.

Bridges over canals and rivers within cities are usually low, as the level of the streets is not much above the highest level of the water, as in Paris, Berlin and Amsterdam. In cities in mountainous regions, bridges are placed high above the point of view; reference is here made only to the chain bridge in Freiberg in Switzerland. It seldom suits wagon traffic to raise the bridgeway too much at its middle, so that in cities like Amsterdam the towpath must be lowered on account of the many bridges spanning canals, causing transport of freight on the canals to take other routes. If the bridge spans a stream so that its sides cannot be seen (Fig. 439), it is then erected as a structure purely utilitarian. But if streets extend along the banks or passenger steamers pass under the bridge as in

Paris, there is opportunity for an esthetic treatment of the sides of the bridge. Thus many city bridges, the Seine bridges in Paris, Arno bridges in Florence, Moldau bridge in Prague, Elector's bridge in Berlin and others, are treated and decorated as architectural works. The motive of the decoration of bridges of symmetrical form as stated in former Chapters, is furnished by the arrangement of abutments and piers; in large iron bridges any decoration desired is concentrated on the piers, while scarcely anything is added to ornament the bridge itself.

In the selection of the mode of construction lies a principal means of giving a pleasing appearance to iron bridges, and this should be carefully considered for large iron bridges in cities as far as circumstances permit, so that they not only satisfy material and also esthetic needs, and the monotonous lattice and ugly Pauli bridges should therefore be avoided. The bridge over the Rhine at Coblenz is one of the most pleasing iron bridges, and it springs over the stream in a single arch. Arched bridges are generally most pleasing when in a single arch like nearly all bridges over the Seine at Paris. It is only admissible to cover the construction with plates for smaller iron structures, and great bridges must produce a pleasing effect by the division of the masses.

The principal decorations of bridges always consist of an architectural treatment of the caps of the piers. The end portals and the caps of the intermediate piers, besides the structure itself, give the bridge a special stamp. The end portals are either towers, as at the bridges over the Rhine at Strasburg and Mannheim, where double portals are constructed on account of the double tracks of the railway; the foot ways on e each side lead to the arrangement of two large and two smaller entrance openings, or if the bridge is to serve for wagon traffic at the same time, to the use of three large and two small gateways. Or the end portals are flanked by towers, as in case of many bridges in fortified cities (Mayence, Coblenz and Dirschau bridges). Tower portaly may receive the richest architectural treatment.

The most beautiful decoration of intermediate piers consists of bridge chapels, great favorites in the middle ages. Small structures for various purposes may be erected in their places.

a lookout tower may also be built on the central pier.

The chains of chain bridges require a special support at each bridge pier, that usually takes the form of a tower. The appearance of the chain bridge over the Danube in Budapest is very stately and dignified; the series of portals and the lines of the chains of the structure itself produce a pleasing effect.

On smaller bridges in cities a favorite idea is to substitute separate statues or groups for the end portals, to decorate the middle pier by a monument as on the Elector's bridge in Berlin, the old bridges of Frankfort and Prague, and the posts of the railing are made posts for gas lamps. It is likewise very proper to widen the foot ways by corbelling out the tops of the piers, as in the bridge over the Rhine at Basle, where semicircular pier caps are furnished with seats.

The railings of stone bridges are preferably solid and also of stone, or perforated and made of brick in smaller bridges, or are balustrade railings, and are made of wood for wooden bridges or of iron for iron bridges. In the first case, the railings are parapet walls extending between pedestals, which may serve to support lamp posts for gas or electric lights; i in smaller bridges the railings may be treated as lattice girders producing a structural effect. Railings of wooden bridges are usually constructed of an external covering of boards, like balustrades of galleries and may be made of fret-sawed boards. Completely covered wooden bridges were formerly favorites, covered stone bridges are rarer, like a bridge over the Arno at Florence, where a corridor passes over shops and connects the Uffizi and Pitti palaces.

All structural decoration is generally rejected in case of ramps, quay walls, retaining walls, etc.; rusticated masonry,, cyclopean masonry, and all bold and solid masonry are best suited for these. The middle ages and Renaissance were not always satisfied in such cases to consider merely the material needs; engineers were always too much artists, and artists were too much engineers, to be pleased with a bare wall without decoration. By corbelled bays, battlements, sculptured coats of arms, emblems of cities, reliefs and angle towers, and similar expedients they sought to relieve the monotony of their walls; if these were walls of fortifications, then the preceding expedients were added to the elements of military

architecture, making interesting esthetic decorative works of city walls, ends of bridges and city gates. The entire quay w wall in Höchst on the Main is even decorated by a late Gothic round arched frieze ornamented by lilies.

Walls of large docks for receiving ships, as well as those of harbors, are usually flat and plain, which is best suited to their purpose; cranes anf other machinern for loading, wood posts and iron rings for mooring vessels, landing stages and stairs, belong to such shore walls. Sheds for goods, custom houses, covered halls for sailors, light houses, waiting rooms for the public, ticket offices, restaurants, hotel gardens and similar accessories, give the shores and harbors their special stamp according to local conditions. One of the most beautiful harbors is that of Genoa with its great portico; one enjoys t the magnificent view of the ships and the activity on shore.

Our modern insipid era has done little to make the treatment of harbors more pleasing; still something has been done of Lake Constance in this respect; the harbors of Constance, Lindau, Friedrichshafen, are known for their beautiful designs. Geneva also possesses beautiful quays, as well as parts of Naples, T Trieste and Leghorn., in their quays decorated by gardens. Other cities famous for beautiful harbors and shore promenades are Dover, Havre, Brighton, Kiel, Hamburg and Portsmouth on the I Isle of Wight. The very large quays in London and other sea p ports serve exclusively for material needs, so that attention is paid only to architectural considerations, so far as to locate magnificent buildings in their vicinity, railway stations, hotels, warehouses, etc.; these large and really splendid structures give to such harbors and quays a specific esthetic character.

Y. LIGHTING OF CITIES.

This is preferably by gas and electricity, and requires lamp posts for supporting the lights. Since cities require a large number of lamps, cast iron is usually employed as the material of lamp posts; it is proper to make the pedestals of stone for large lamp posts, such as are usually erected before palaces and public buildings or on squares. It is even advisable to treat the pedestals as columns for sake of economy, and because they may also be used as posts for stopping carriages. In many places such columns are also used for supporting a clock, thermometer and barometer, a leaden plate being hinged

to their lower part, that it may be turned like the leaf of a book, and on it may be painted a plan of the locality, addresses, times for visiting things worth seeing, etc. The lower p part of the lamp post is made wider and may be treated like t the classic tripod, or the lower part of a vase. The shaft can de diminished upward and is also best treated in imitation of the antique candelabra and similarly decorated, usually crowned by a freely treated Corinthian capital, which supports the lamp or a circle of lamps, with angular or scroll arms radiating from the centre. The lamps may be placed in a circle or in several tiers above each other, forming groups of three, four or five. It is usually expected to obtain from such groups better effects than they actually produce, for a pyramidal group does not appear so well from beneath, as does the simple arrangement in a circle; still the size of the lamps will decide t which arrangement should be preferred. When burners are used without glass shades, as in circular crowns of gas lights, the space required for each is less than if shades were used, which both protect the light from wind, modify and disperse it. Reflectors are often placed behind the lamps.

The lamp posts as works in cast iron admit of the most varied treatment in detail; zinc or bronze is rarely used for lamp p posts except in enclosed rooms, and wrought iron is only for lanterns in private houses, since these metals are too costly to be used for the great number of lamp posts needed in a city. Cast zinc posseses too little strength unless the material is quite thick, to be exposed to injury in the open streets, that might deface the lamp post.

2. DECORATIONS FOR FESTIVALS.

These serve temporary purposes, therefore excluding everything monumental, employing expedients of very diverse kinds, according to the season of the year, in which they are erected, such as standards and flags, garlands of leaves and fir branches, wreaths of flowers, triumphal arches and gateways built w with a wooden framework, over intessections of streets, tapestries, draperies, ornamental paintings, emblems and moats of arms, decorative objects of all kinds made of gypsum, paper and clay, tablets with inscriptions, illuminated transpaeencies, etc. For festivals and ceremonies when the court and government or city officials appear on a special square, and the spectators

concentrated, raised amphitheatres, pavilions for the court a and officials, and music stands are necessary, while for musical festivals, for shooting contests or tournaments, large assembly halls, restaurants, offices and similar subordinate rooms for various purposes are needed.

For our era world's exhibitions take the place of Olympic games of the Greeks, and contests of animals and men in Roman amphitheatres. Almost all larger cities have their buildings for industrial exhibitions, wholly or partly devoted to local exhibitions, for musical contests, art exhibitions and other purposes. The world's exhibitions in addition to the halls of exhibitions require a multitude of annexes, restaurants and p places of amusement, kiosks, and special designs of which as little may be said in a general way as of decorations for festivals. Local conditions, customs and usuages, character of the festival and that of preparations for it, govern the decision for expedients to be used in the decoration. Thus the character of the festival and decorations will be decided by the mourning of a solemn funeral ceremony or by the joy of a festival.

Festivals of all kinds may be collected under certain general points of view. Church festivals have their peculiar character, determined according to the sect, and recur annually like Corpus Christi day in Catholic cities, or as in the next group they may be regarded as historical and are festivals of greeting at the installation of a recently elected pope or a newly appointed prince of the Church, or may be any jubilees.

Historical festivals are those connected with a prince, like those just mentioned, when the more important days, coronation, marriage, victorious return from war, birth and death, are commemorated. A third category includes all popular festivals of music, singing, shooting and gymnastic contests, that recur annually or periodically, like the October festival in Munich, Bird-meadow festival in Dresden, People's festival in Cannstadt. To these are allied the traveling collections attended by professionals during Pentecost, and finally the great exhibitions that terminate in late summer or autumn, according to their importance, or world's exhibitions, which usually last from May till the end of October.

THE END.

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